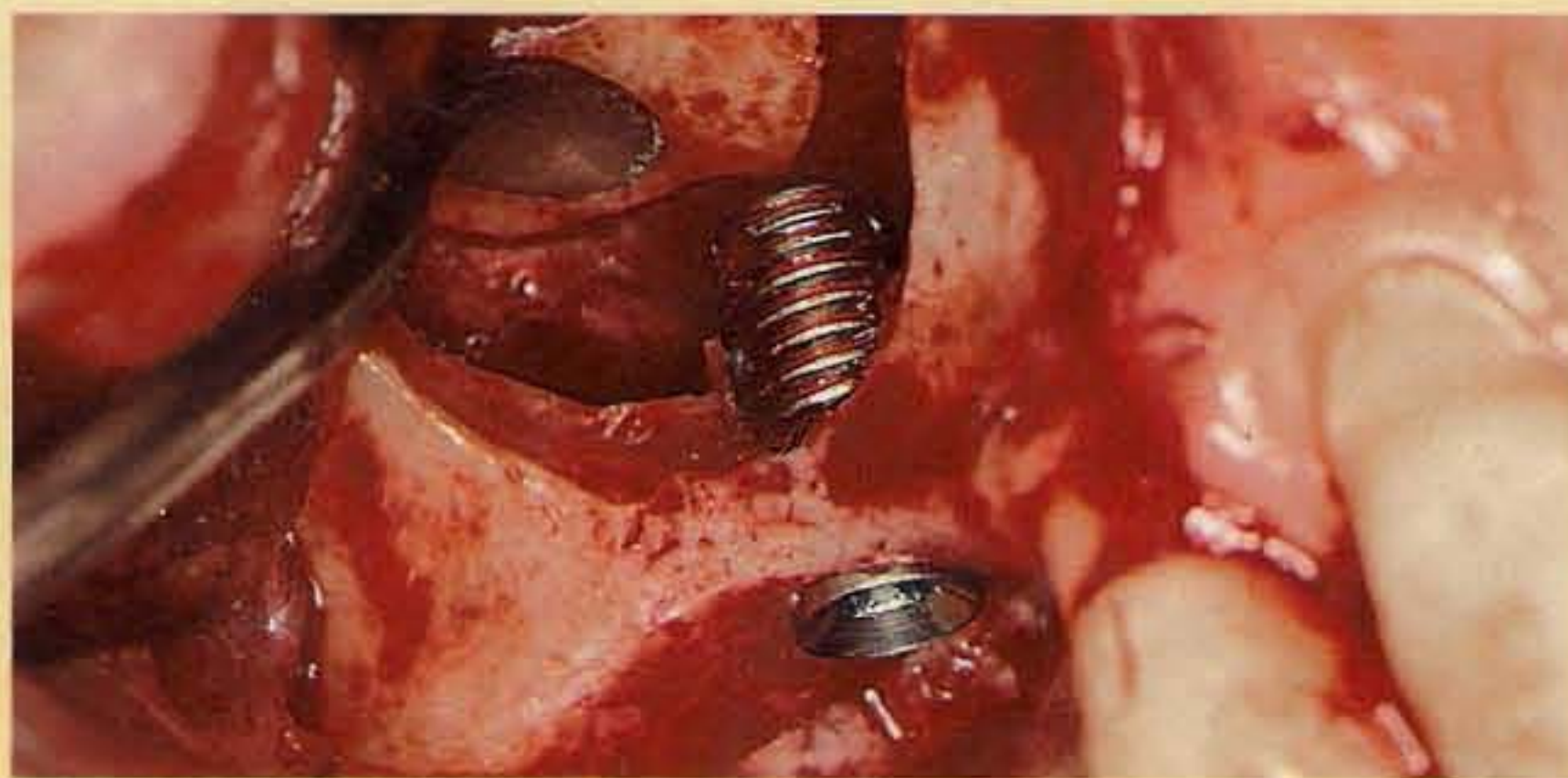
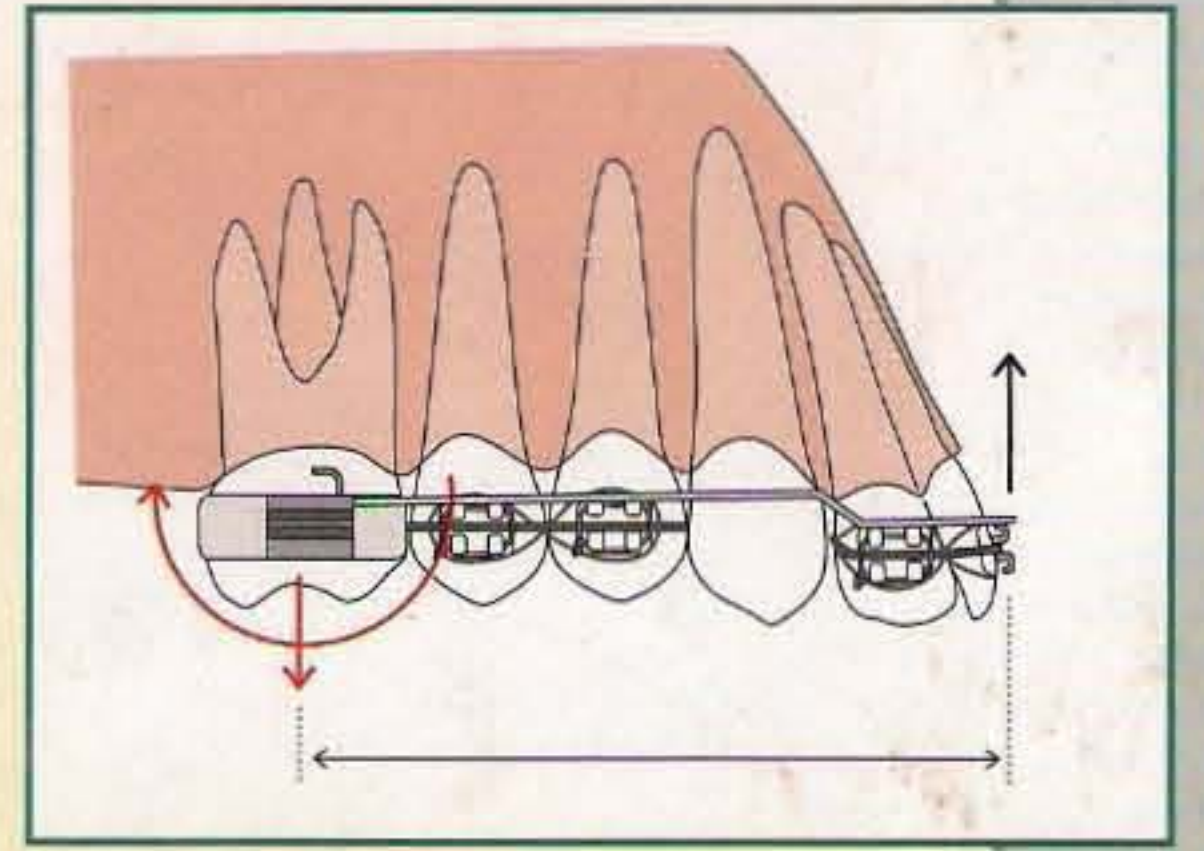


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Prosthetic Rehabilitation



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Prosthetic Rehabilitation

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Dedication

To the professors of the University of Turin—Dino Roccia, Giuseppe Ceria, and Remo Modica—who, more than anyone else, contributed to the development of the School of Dentistry in the late 1950s with their hard work, their passion for dentistry, their professionalism, and their dynamic teaching. The Section of Oral and Maxillofacial Rehabilitation was established in the mid 1970s in the culturally favorable environment created by these professors.

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Foreword

The last two decades of the 20th century were extraordinary ones for my discipline of predilection—prosthodontics. They ushered in a strong biological focus, which gradually matched and perhaps even eclipsed traditional exclusive concerns with dental materials and techniques. The change was an inevitable and welcome one, and it belatedly paralleled the shift toward emphasis in basic and clinical sciences that had influenced development in the discipline. Neurophysiology, bioengineering, and health economics emerged as profound concerns in the effort to provide predictable treatment outcomes that recognized both patient as well as dentist-mediated concerns.

It is perhaps impossible to identify a specific text or event that catalyzed the much-needed changes. Most seminal events in history or breakthroughs in science tend to have similar origins—often unrelated, but ultimately convergent occurrences. Small streams of thought and experiment gradually converge to create a river full of force and momentum, which will in turn irrigate new sources of creativity.

My own academic development was influenced by particular Scandinavian works. The first was the 1977 article by Brill et al, “Ecologic changes in the oral cavity caused by removable partial dentures.”¹ The second was the 1977 monograph by Brånemark et al on osseointegrated implants.² Both authors indirectly framed the prosthodontist’s twin concerns that must dominate evidence-based clinical decisions. These concerns can be posed as two questions: (1) What is the biological price paid as a result of the diverse sequelae and consequences of loss of teeth? and (2) What is the biological price inherent in the prosthodontic intervention? The very perceptive, if understandably limited, ecologic focus of Brill et al¹ gradually expanded from the notion of adverse ecologic shifts to far beyond those of plaque-induced and mechanical trauma. Brånemark et al,² on the other hand, proposed an entirely new model in pursuit of understanding the therapeutic benefits resulting in a scientific transition from an uncontrolled to a controlled induced interface. The impact of both ideas cannot be underestimated, particularly in the context of the subtle, yet profound, differences in dental, as opposed to medical, biotechnology.

Prosthodontics has been in the “spare parts” business for a long time, although we have done it with only a small degree of the anguish found in the medical field. As a result, we have not been unduly burdened with the sort of tricky ethical questions associated with genetics and organ transplantation.

However our commitment to enriching our patients’ lives, rather than prolonging them, demands the same degree of scientific rigor in the way we make clinical decisions and carry out prosthodontic therapy.

The need for outstanding texts which articulate this new vision for prosthodontic rehabilitation has therefore become a serious and major priority. Professor Giulio Preti and his colleagues have provided us with such a text, and all of us in the discipline have been enriched by this masterful effort. I have been studying the Turin team’s contribution to dental scholarship—research, education, service—for several years, and theirs has been an exemplary record of commitment and leadership. They have distilled an enormous body of knowledge and wisdom in writing this book and presented their convictions in a lucid and highly organized manner. I have little doubt that this contribution stands out amongst those distinguished texts in the all-too-small canon of significant works in prosthodontics. Above all, the publication of this book is a compelling testimony to the purpose and meaning of clinical academics’ lives. Giulio Preti and his Turin colleagues deserve our gratitude for their outstanding contribution.

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Preface

There can be no doubt that scientific advancement is today articulated by papers published in specialized journals. Such articles measure the progress made by research, even when the truths they state are subsequently denied or enriched by the onward march of research. The sum of articles published by a research group or a school is a chronicle of what they have contributed to a field of research. But a book . . . a book is not part of a chronicle. Rather it expresses the history of the steps through which a school was born, matured, and changed—in short, its evolution.

Over the years, two philosophies have had a strong positive influence on our thinking: the Zurich School, with Professor Albert Gerber and Professor Sandro Palla, which remains a constant reference point for continuing and new students alike; and the UCLA School of Dentistry, first with Professor Jim Krachtovil and now Professor John Beumer, in a collaboration of more than 20 years that has contributed to the education of several of our collaborators in the difficult art of maxillofacial prosthetics. In addition, Professor Remo Modica has become our maestro in life as well as in our profession. These individuals, with their enthusiasm and their commitment to the psychosocial aspects of prosthetic rehabilitation, have strongly influenced the direction our school has taken.

During the last 25 years of teaching, treatment, and research, our biennial congress has provided us with an opportunity to compare our progress against the world's most prestigious schools. Since then thousands of patients have been treated and hundreds of students trained in our department. Some of our alumni are now professors in various Italian universities including Bari, Bologna, Brescia, Ferrara, and Genoa. Each of these institutions is committed to giving continuity to the tradition of our school. Today, both our alumni and I believe we have achieved sufficient maturity to communicate our philosophy through this book. This publication represents 25 years of collective knowledge and experience. Each book tells a story, and we would like to think that this is our story.

Although this book is the product of many authors' work, it has a uniformity of thought, thanks to our common approach



Boves, Italy, July 2001, from the left: Professors Bassi, Carossa, Bucca, Preti, Pera.



Boves, Italy, July 2001, a working group.

and the professional contacts we have maintained over the years. In compiling this book, two fundamental concepts have been dominant: our teaching methodologies and the importance of providing supporting documentation from the literature. Today, when critically analyzing the effectiveness of new therapies, the predictability of post-therapeutic success has become crucial. Following in the wake of evidence-based medicine, evidence-based dentistry has now arisen, and within this, evidence-based prosthodontics. This approach can only help our discipline make better progress, where in the past, randomized controlled trials were rare.

Scientific progress in prosthetic dentistry has, nevertheless, not yet led to the large-scale adoption of new improved therapies. For example, implant dentistry offers enormous therapeutic possibilities, but only a tiny fraction of the population has been able to benefit from this treatment. When treatment costs are high and patients' economic situations must be taken into consideration, traditional therapies maintain their value in comparison to new methods of prosthetic rehabilitation.

This text discusses diagnosis and the necessary toolkit. Diagnosis considers systemic, psychological, and functional



Cinzano, Italy, October 1978, on a seminar with Prof Gerber.



Pecetto, Italy, October 2001, a seminar for writing the book.

aspects. The toolkit comprises the basic knowledge of the disciplines that make up the indispensable corollary for oral rehabilitation: periodontology, pre-prosthetic orthodontics, endodontics, and osseointegrated implant dentistry.

Some of these chapters have been written by our alumni who, while having worked as independent practitioners over the years, have maintained their professional ties with our department of prosthodontics, within which they have played or still play an active consultant role. These chapters, far from being exhaustive for those who are experts in the subject, discuss prosthetic aspects with two goals in mind: (1) to emphasize our department's philosophy of "comprehensive care"; and (2) to make the reader aware of his or her limits so that, on a case-by-case basis, he or she will refer or consult with a specialist as required.

The multidisciplinary approach to prosthetic rehabilitation of the oral cavity is a complex process that proceeds through diagnosis and application of the necessary technical knowledge to design and construct a prosthesis to ensure long-term success.

Diagnosis must begin from the perspective of internal medicine. Dentists' knowledge of this field has become increasingly important because of the increased frequency with which we encounter patients with chronic systemic diseases that, though severe, can today be controlled. These diseases may influence our rehabilitation strategies. In these patients the dentist must anticipate the possible side-effects of treatment and any situations that predispose the patient to risk.

Prosthetic treatment that modifies the oral cavity inevitably must consider the patient's physical as well as emotional needs. It is thus important to ensure correct communication so that we

may understand our patients from psychological, social, and cultural points of view.

Diagnosis continues with morphostructural and functional evaluation of the stomatognathic system. Whereas the former has long been considered indispensable and is routinely carried out, the same cannot be said for functional evaluation. Failure to appreciate disorders of the stomatognathic system before beginning treatment is frequently the cause of treatment failure.

The ecosystem of the oral cavity is modified by the presence of the prostheses, which may have a highly destructive effect if the mechanisms involved are not properly understood. Knowledge of these mechanisms is based on the awareness that long-term success of the rehabilitation is the product of patient compliance and consistent follow-up by the dentist.

No dentist can neglect a careful evaluation of his or her patient as a whole, from medical history to social and psychological status, before formulating a personalized treatment plan. For this purpose we propose a guide to diagnosis and to the prosthodontic treatment plan in which, among other factors, every treatment considered ideal must then be adapted to the requirements of the individual patient.

In the final analysis, the treatment plan must address the articulated or perceived concerns of each patient. These important determinants of any successful treatment outcome include a symptom-free, esthetic, and functional result that does not incur risks of morbidity or unnecessary expense.

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An Explanation of the Criteria Used for Evaluating the Dental Literature

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Man prefers to believe what he prefers to be true.
Francis Bacon, *Novum Organum*, 1620

Experiments are the only means of knowledge
at our disposal; the rest is poetry, imagination.
Max Planck

A new scientific publication is the product of authors elaborating on the present knowledge of a specific subject through the mediation and integration of their personal experiences. A scientific text is, therefore, the product of detailed research from many sources that is presented in a natural and logical order. The success of this process is based on the ability of the authors to explain their arguments and the validity of what they have written. Even if the reader can easily judge the quality of the authors' ideas, this is not the case for the scientific accuracy of the ideas cited from other sources. How many readers take the trouble to check the bibliographic sources cited in a text? In order to provide readers with an additional means to substantiate their learning, every reference cited in this volume has been ranked by scientific weight, following the evaluation criteria and methodology published by Jacob and Carr.¹ In particular, every reference has been categorized according to the type of article (Table 1).

Scientific Validity

Technological innovations of the last 20 years have forced dentists to acquire new knowledge and techniques to stay in step with the advances in the profession. Remaining up-to-date and assessing the efficacy and safety of new products, procedures, and techniques are becoming increasingly difficult, if not impossible, given the constant flow of information (not always of

high quality) presented in scientific journals, textbooks, and continuing education courses.

Making sense of these often contradictory sources requires a new skill—that of being able to select information that is valid and useful in clinical practice. The questions that dentists must pose to themselves are: (a) Is the information scientifically correct, and if this is the case, is it new and valid? and (b) Is it clinically important? We propose a hierarchical scale of assessment (see Table 1), based on the quality of the experimental evidence, to assist clinicians to select therapies for their patients that are supported by reliable verified data and to set aside those based only on personal opinion or equivocal data. Differences in scientific weight are determined by the type of source and the type of experimental study from which the data are obtained. The clinical relevance and practical utility depend instead on external evaluation of the research.

Sources

Scientific information that is the product of valid and repeatable experiments is published almost exclusively in professional journals that use a review system for selecting articles for publication. Such information is rarely obtained from books, courses, or continuing education conferences. Textbooks logically present the results of research that has already been published, and so is not new, as well as the opinions, usually implicit, of the authors. Often new results of experimental research are presented for the first time at conferences. However, given the limitations of the lecture format, it is not possible to present all of the information needed to evaluate or replicate the results of the studies and therefore determine their veracity. In addition, much research presented at conferences is not subsequently published.

All dental journals do not have the same scientific importance. The most prestigious journals ensure that all articles are evaluated by a group of experts (peer review) before being accepted for publication. Other less rigorous journals accept articles at the discretion of the editor alone.

One system of valuing scientific journals, called *impact factor* (IF), is based on the number of citations of the journal or its articles found in other journals. The IF index thus permits a valuation of the scientific weight of a publication. Articles published in a journal with a high IF have greater probability of being considered valid by the scientific community.

It is timely to recognize that nearly all dental journals that have a high IF are published in English. As in the 17th century the language of music was Italian, so in the 21st century the language of science is English.

Types of Scientific Articles

The Council of Biology Editors has defined a *scientific article* as “the first publication containing sufficient information to allow colleagues to understand the observations, repeat the experiment, and evaluate the intellectual process.”² Clearly this definition is based on scientific methods enunciated by Bacon and Galileo in the 17th century. Essentially, to determine the validity of information, it is necessary above all to verify the methodology by which the study was made. For this reason, we have classified the various types of articles based on the hierarchy proposed by Jacob and Carr¹ (see Table 1).

Personal communications

Not everything printed in scientific journals is scientific. Personal opinions expressed as editorials, letters, or contributions to round table discussions are usually cited as *personal communications*. They are judged as hypotheses, ideas, opinions, and comments that are not to be confounded with data of scientific relevance, especially if the primary argument concerns questions that can be tested in experimentation. More rigorous critical evaluation must be applied to informative leaflets provided by manufacturers to publicize and promote the sale of their products.

Case reports

These articles introduce a new technique or results of a new product used in a limited number of cases. Their scientific importance is exclusively chronological, only establishing the author as the first person to propose the innovation. It is clearly impossible to draw extensively applicable conclusions based on the results of one or two cases that were followed for a very limited time period and, above all, derived from observations that have no analytical design.

Reviews of the literature

Traditional review articles are narratives, often the work of only one author, that comment on publications on a specific topic, in a uniform fashion, from the author's point of view and experience. The scientific data reported in such articles are drawn from various types of studies, often not selected in a systematic manner, and not evaluated in a standard mode. Reviews with these characteristics, though useful as a synthesis of a particular argument, risk presenting conclusions that are not reproducible and that reflect, in some measure, the opinion of the author as well as those expressed in the reviewed literature.

In vitro experiments

In vitro experiments are carried out in laboratories using models to, more or less, reproduce clinical reality. They are the overwhelming majority of studies published in dentistry and prosthodontics because of the ease of execution and limited expense. Numerous types of models are used, including mechanical, computerized, and those using extracted teeth. The conclusions that can be drawn from such experiments are often difficult to accept as conclusive scientific proof, due to their evident limitation as only partially reproducing the clinical reality, which is decidedly more complex and practically impossible to represent using such defined models.

Animal studies

Animal studies provide a first approximation of what happens in the human oral cavity; the higher the animal subjects are in the evolutionary scale, the better the experiment will approximate results found in humans. Because animals can be sacrificed in experiments, important data can be obtained, particularly in the area of histology. Obvious differences between the oral cavity of animals and that of humans, however, limit the validity of this type of study.

Clinical studies

Studies with consenting humans are without doubt the principal sources from which we can draw reliable information for daily clinical practice. For the numerous types of clinical studies, the scientific weight increases as study variables that may influence the results are strictly controlled. Schematically, clinical studies can be divided into two primary categories: (a) *analytical studies*, in which there are two groups of subjects, one that receives the experimental treatment and the other that serves as a control; and (b) *descriptive studies*, in which there is no control group. These categories, in turn, can be subdivided into

two types: *experimental*, in which treatment is assigned to randomly defined groups of subjects according to a research protocol; and *epidemiological* or observational, in which the treatment is assigned to subjects without the control of the researcher.

Experimental studies

Prospective controlled, randomized studies, in which the experimental treatment is assigned to two homogenous groups, represent the “gold standard” on the methodological plane for evaluation of efficacy. In a randomized controlled trial the inclusion of a group of subjects that is identical to the group under treatment serves as a control to verify the real efficacy of the therapy or the experimental diagnosis. For example, in pharmacological investigations, the control group is given either a pharmaceutical placebo or a drug that is considered the present standard treatment. In these studies, it is important that the distribution of the subjects between the two groups is completely randomized and double blind, in which neither the participating patients nor the researchers know which type of treatment is being followed. This allows a probable uniform distribution of the various prognostic factors and of possible unpredictable variables.

Studies in which subjects are assigned to a group in a manner that is not completely random are known as *quasi-randomized controlled trials*. When the control group is made up of the same subjects who receive the various treatments (experimental and comparative) in two different periods, this is called a *randomized cross-over trial*.

Observational studies

Nonexperimental epidemiological studies can be of two types: (a) *case controlled studies*, in which a group of subjects with a certain problem are confronted with a homologous control group that do not have the problem to identify the relevant factors that might be responsible; and (b) *cohort studies*, in which subjects who have received different treatments are followed over time to evaluate the incidence of relevant clinical events.

Systematic review of the literature (meta-analysis)

Systematic literature reviews are conducted according to a rigorous and explicit protocol that prescribes criteria for the search, selection, and evaluation of the literature on a defined topic. Meta-analysis studies gather together and statistically analyze similar clinical studies, often with limited samples, providing reliable scientific data because of the overall higher numbers of

subjects involved. Fundamental to this kind of analysis is the comparability of the various clinical studies taken together. The scientific relevance of these analyses is given by the affiliation of the studies that are compared.

Descriptive studies

Clinical studies are defined as *descriptive* if an analytical control of the experiment is not possible because of the lack of subjects that can act as a control group. If the therapy or the diagnostic procedure for analysis was already accomplished before the patients were selected for the study, it is called a *retrospective study*. If, instead, the individuals were selected prior to the experiment proceeding, it is a *prospective study*. Because of the possibility of controlling patient participation and the execution of the study, prospective studies are more relevant from the scientific point of view than retrospective studies.

Conclusion

The majority of studies presented in the prosthodontic literature fall into the categories described here. Undertaking experimental or observational studies is very difficult because of practical concerns (eg, the difficulties of always having a control group), economic funding (ie, scarce economic resources available for dental research), and the high degree of individualization in prosthodontic therapy.

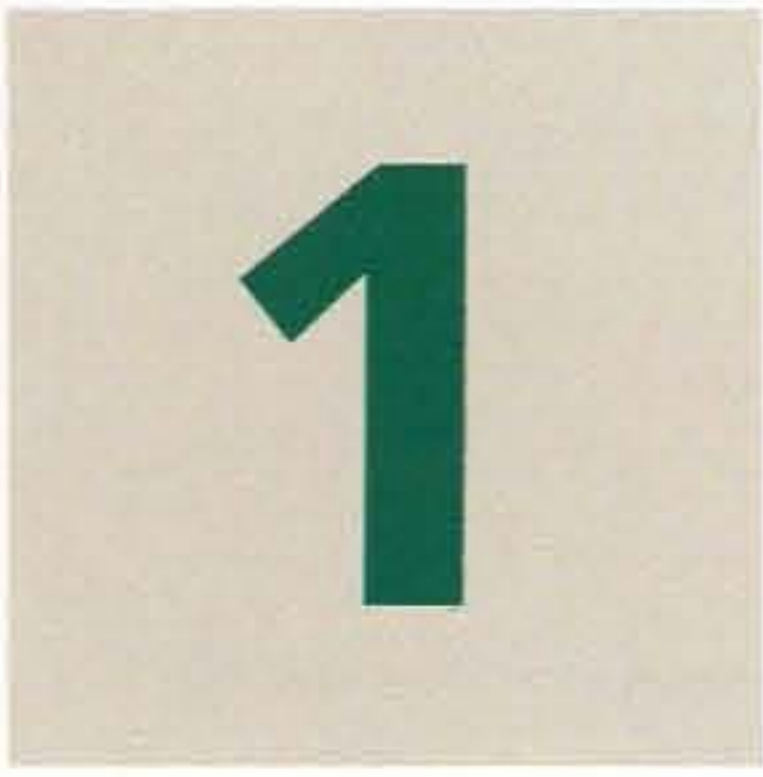
Most articles in the prosthodontic literature are derived from in vitro studies, which are easier and more economical to carry out but of inferior scientific weight. The few clinical experiments of long duration concern, above all, retrospective epidemiological analyses without control groups. Despite the infrequent publication of prospective clinical studies, such articles (eg, work on implant osseointegration) have been essential to advancements in dentistry in recent years.

Table 1 Evaluation categories for cited references

Category 1	Experimental clinical analytical studies
Category 2	Observational clinical analytical studies
Category 3	Prospective descriptive clinical studies
Category 4	Descriptive clinical studies
Category 5	Animal studies
Category 6	In vitro studies
Category 7	Books and narrative reviews of the literature
Category 8	Case reports
Category 9	Personal communications

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Assessment of the Patient's General Health

The meeting between a dentist and a patient who has prosthetic problems and is in need of oral rehabilitation must be recognized as a full professional medical relationship. From this first contact, the dentist must establish a trusting relationship with the patient, in order to investigate any problem that may influence the outcome of the treatment strategy, evaluate any increased risk of collateral effects, understand conditions that may represent risks for the dentist or dental team, and assess the emotional condition of the patient. Furthermore, this meeting is an opportunity to identify known or suspected clinical problems for which the patient should be referred to a physician for care.

This chapter aims to provide both guidelines and specific proposals for a management approach to these internal assessments along with a summary of diagnostic-interpretative symptoms and therapy for reference. Knowledge of internal medicine by dentists has become even more important because of the greater number of patients affected by chronic, even severe diseases that a few years ago were rapidly fatal but now are well controlled by relatively new, efficient therapeutic approaches that prolong life: hemodialysis, vascular bypass, valve replacement, chemotherapy, and organ transplantation.

Approach to the Patient

The most effective holistic examination of the patient is best performed during the first appointment. At this meeting, in addition to discussion of the immediate oral problems, it is important to dedicate time to getting to know the patient and his or her general clinical history.

Setting

The setting of the first contact with the patient is very important. Ideally, this meeting should be in the dentist's office rather than in a clinical room. Respect the appointment time, call the patient by the correct name including title, and show clear pro-

fessional interest in the problems the patient is describing. Expressing care and concern is fundamental for establishing a relationship that will be favorable for coping with possible emotive situations and behavior that may arise during treatment.

General medical and clinical history

The clinical history is indispensable to an overall clinical picture of the patient's health, because this information will reduce errors and unsuccessful therapy and preview and prevent complications. The history can be assembled using various interviewing techniques. Before the direct questioning, the patient can be asked to complete a printed questionnaire (Figs 1-1 to 1-3), thus providing a brief overview that is then completed by the dentist during questioning. These questionnaires provide lists of symptoms regarding different organs or body systems or names of diseases, as well as questions about use of drugs that can help identify patients' health problems.

These questionnaires can pose difficulties for some patients, for example, those with a very low level of schooling. For such patients, it is essential to question them directly in appropriate language, verify that the questions have been understood correctly, and that the answers given are clear.

The direct interview, although clearly more time consuming, usually provides more complete information. Furthermore, it is possible in a direct interview to ask for information (eg, about hospitalization, medicines and pharmaceuticals being taken, and complications that occurred in interventions) that may provide information about health problems in an indirect fashion. Several examples of effective questions are described in the next paragraphs.

Are you being cared for by a doctor?

If the patient answers "yes," the dentist should ask what the specific problem was, what diagnosis was given, what ongoing problems remain unresolved, and what treatment is being given. If the patient has regular medical examinations, the dentist should try to clarify whether these visits and analyses had

Personal information

Name _____ Date _____

Age _____

Address _____ Telephone number _____

Medical history for each anatomic system

General	Variation of weight	☐	Digestive system	Dysphagia	☐
	Anorexia	☐		Acid reflux	☐
	Asthenia	☐		Heartburn	☐
	Fever	☐		Nausea/vomiting	☐
	Abnormal sweating	☐		Bloody vomit/black, tarry stools	☐
Skin	Rash	☐		Abdominal pain	☐
	Itching	☐		Constipation	☐
	Ulcers	☐		Meteorism	☐
	Petechiae/ecchymoses	☐		Food intolerances	☐
Head	Headache	☐	Urinary system	Polyuria/nocturia	☐
	Loss of consciousness	☐		Diuria/pollakiuria	☐
	Trauma	☐		Hematuria	☐
	Convulsions	☐		Abnormal secretions	☐
Eyes	Alteration of sight	☐	Reproductive system	Amenorrhea/metrorrhagia	☐
	Pain/redness	☐		Vaginal secretions	☐
	Diplopia	☐		Anomalies	☐
	Scotoma/phosphene	☐		Impotence/frigidity	☐
Ears	Excessive tearing	☐	Locomotor apparatus	Muscular or articular pain	☐
	Alterations of hearing	☐		Rigidity	☐
	Vertigo	☐		Articular swelling	☐
	Otorrhea/otalgia	☐		Thoracic pain	☐
	Respiratory system	☐	Cardiovascular system	Stress dyspnea	☐
	Nosebleed	☐		Orthopnea	☐
	Posterior rhinorrhea	☐		Paroxysmic dyspnea	☐
	Pharyngalgia	☐		Palpitations	☐
	Dysphonia	☐		Cyanosis	☐
	Cough/sputum	☐		Edema	☐
	Hemoptysis	☐		Claudication	☐
	Dyspnea	☐		Hypertension	☐
	Sibili wheezing	☐			
	Pleuritic pain	☐			

Other information

- ☐ Hospitalizations
- ☐ Surgeries
- ☐ Allergies
- ☐ Allergies to pharmaceuticals and type of reaction
- ☐ Previous administrations of local anesthesia
- ☐ Current medical treatments

Name, address, and telephone of physician: _____

Notes:

Fig 1-1 Medical history questionnaire.

Personal information

Name _____ Date _____

Age _____

Address _____ Telephone number _____

Information about your health history

1. Have you been to see your doctor in the last 2 years? ☐ Yes ☐ No
If yes, for what reason? _____
2. Write the name and address of your physician. _____
3. Have you been hospitalized in the last 2 years? ☐ Yes ☐ No
If yes, for what reason? _____
4. Have you ever had surgery? ☐ Yes ☐ No
If yes, what type? _____
5. Were there any complications? ☐ Yes ☐ No
If yes, what were they? _____
6. Have you had bleeding problems that required intervention from a physician? ☐ Yes ☐ No
7. Are you allergic to any medicines? ☐ Yes ☐ No
If yes, what type of reaction? _____
8. Have you had any undesirable reactions to an anesthetic during dental treatment? ☐ Yes ☐ No
If yes, what sort of reaction? _____
9. When you climb stairs or take a walk, have you had to stop because you had a pain in the chest or were breathless? ☐ Yes ☐ No
10. Do your legs get swollen? ☐ Yes ☐ No
11. Do you sleep with more than two pillows or do you sometimes awaken feeling breathless? ☐ Yes ☐ No
12. Has your weight increased or decreased by more than 2 kg in the last year? ☐ Yes ☐ No
13. Are you pregnant? ☐ Yes ☐ No
Could you be pregnant? ☐ Yes ☐ No
Do you use birth control pills or precautions? ☐ Yes ☐ No
14. Are you currently taking any medicines? ☐ Yes ☐ No
If yes, which ones? _____
15. Underline the words in the list that you have heard during discussions of your health:

Hepatitis	Fainting	Artificial valve	Emphysema
Liver disease	Psychotherapy	Ictus pacemaker	Venereal diseases
Icterus	Psychopharmaceuticals	Fistula	Herpes
Transfusion	Anxiety/depression	Bypass	AIDS
Drug dependency	Uncompensated heart condition	Renal problems	Chronic diarrhea
Hemophilia	Myocardial infarct	Ulcer	Enlarged glands
Anemia	Angina pectoris	Arthritis	Glaucoma
Diabetes	Hypertension	Tuberculosis	Cortisone therapy
Goiter/hyperthyroidism	Heart murmur	Chronic bronchitis	Chemotherapy
Kidney disease	Rheumatic fever	Asthma	Cobalt therapy
Epilepsy	Mitral valve prolapse	Sinusitis	Allergies
16. Have you had any other diseases or health problems that are not listed in this questionnaire? ☐ Yes ☐ No
If yes, which ones? _____

Signature _____

Notes (for staff use)

*Modified and adapted from the questionnaire used by the University of Kentucky, College of Dentistry

Fig 1-2 Patient-completed health history questionnaire.*

Personal information	
Name _____	Date _____
Age _____	
Address _____	Telephone number _____
Medical history	
1. Have you ever been hospitalized and had surgery?	☐ Yes ☐ No
2. Are you currently being treated for any disease?	☐ Yes ☐ No
3. Are you currently using any medicines regularly or occasionally?	☐ Yes ☐ No
4. Are you allergic to any medicines or other substances?	☐ Yes ☐ No
5. Have you ever had heart diseases, high blood pressure, or heart murmur?	☐ Yes ☐ No
6. Have you ever had lung problems or tuberculosis?	☐ Yes ☐ No
7. Have you ever had renal/kidney problems?	☐ Yes ☐ No
8. Are you diabetic?	☐ Yes ☐ No
9. Have you ever had anemia or problems of coagulation of the blood?	☐ Yes ☐ No
10. Have you ever had hepatitis or liver problems?	☐ Yes ☐ No
10. Have you had any venereal diseases?	☐ Yes ☐ No
11. Are you at risk for getting acquired immunodeficiency syndrome (AIDS)?	☐ Yes ☐ No
12. Are you or might you be pregnant?	☐ Yes ☐ No
Notes _____	

Fig 1-3 Medical history questionnaire for specific problems.

clinically significant results. Some patients have not been assessed by a general physician for many years; even if a patient declares he or she is in good health, some information elicited from the interview or from direct examination may be cause to advise the patient to seek a general examination by a medical advisor.

Have you even been hospitalized?

This is a question that usually provides useful information about more important past clinical problems. The patient should be asked the reasons for the hospitalization, what interventions were made, the diagnosis made, and if he or she hemorrhaged severely or had negative reactions to the drugs or anesthetics used.

Are you taking any medicines now?

Sometimes patients completely forget to report chronic diseases, because they consider their treatment as a habit. A direct question about medicine being taken can reveal the presence of pathosis. The dentist should try to identify the medicine. Often the patient does not think of mentioning the use of aspirin or similar anti-inflammatories, analgesics, sedatives, laxatives, and

alternative medicine products. It is prudent to ask, "Are you taking any medicine, pills, capsules, syrups, or any other preparations?"

Are you allergic to any medicines?

The examiner should ask the patient exactly which medicine caused a reaction and what happened when he or she took it. Often patients confuse collateral or side effects of a medicine with the general term *allergy* and unjustifiably report alarming reactions such as gastrointestinal disturbances or feeling faint after an injection as an allergy. It is essential that the clinician not rely on the judgment of a patient and instead encourage him or her to recount what really happened. Urticarial cutaneous reactions, angioedema, rhinorrhea, lacrimation, acute dyspnea or dysphonia, broncospasms, and arterial hypotension are characteristic manifestations of anaphylaxis in more or less severe forms; if none of these effects is reported, the examiner should doubt whether a real allergic reaction occurred.

For these reasons, it is prudent to record the address and telephone number of the patient's general medical practitioner.

Physical examination

General

A great deal of objective information can be acquired and inferred by the dentist from simple observation: the way the patient behaves, speaks, moves, and sits; the patient's clothing and appearance; the correlation between the patient's reported age and apparent age; the patient's reactions; and the odors or scents emanating from the patient constitute a disordered but important source of information.

Of particular importance are the so-called vital signs:

- Heart frequency and rhythm
- Blood pressure
- Respiratory frequency
- Body temperature (in certain specific cases)

Acquiring and noting these data during the first visit gives the clinician important referral or baseline information. Possible variations may be manifested during or after an intervention, and only by knowing the baseline parameters can the dentist make an adequate and critical assessment. Collection of this information also may reveal anomalies that were not known to the patient.

Cardiac frequency and rhythm can be easily checked on the radial or carotid pulse. The presence of extra beats, arrhythmia, bradyarrhythmia, or tachyarrhythmia that has not previously been investigated and classified will require that the patient have a basal electrocardiogram or be referred to a cardiologist.

Measurement of the arterial pressure must be made correctly. The instrument, if an aneroid type, must be checked and calibrated at least once a year. The rubber cuff of the armband that compresses the arm must be of the correct size: 12 to 16 cm for people of normal body weight. Obese patients need a larger armband to avoid a false high reading; on the other hand, for very thin people and young children, the use of a shorter and tighter armband will avoid the recording of a false low pressure.

The pressure can be measured on either arm without a preference for the left or right; for elderly patients, it is appropriate to measure the pressure on both arms, because there may be variations caused by the presence of arteriosclerotic deposits in the arterial vessels that will change the propagation of the blood pressure waves with important variations between the arms.

The patient should be seated with the arm completely uncovered and resting on a rigid surface and with the elbow slightly flexed. The hand should not be clenched into a fist. The armband should be completely deflated when wrapped around the arm; the rubber cuff should be positioned over the brachial artery, or a couple of centimeters above the antecubital fossa.

The armband should be applied carefully so that there is no space between the band and the skin.

The pressure is then raised above the maximum, until the radial pulse cannot be felt; the rubber cuff is then completely deflated. The stethoscope is then placed over the brachial pulse (not under the cuff), and the pressure is raised to 30 mm Hg above the maximum; the rubber cuff is then deflated slowly (3 mm Hg/s). The pressure at the moment that an audible tone is heard through the stethoscope is the maximum or systolic arterial pressure; the pressure is lowered further, until the tone is lower and more intense, and the tone then becomes less intense and disappears completely. The pressure that corresponds to the disappearance of the tone is the diastolic pressure.

Respiratory frequency is determined by placing the hand on the patient's chest and counting the number of respirations during 30 or 60 seconds. In adults, the normal range is between 8 and 16 respirations per minute.

The body temperature is a vital sign that should be measured in patients who have symptoms and signs of infection during the first visit. The temperature may be determined either orally or in the armpit; oral values are higher by 0.5°C than the temperature measured on the skin. Normal values are not more than 37.0°C for the internal temperature and 36.5°C for external measurements.

Important information can also be obtained from examination of the uncovered parts of the body: the skin in general, the hands, the neck, and the oral cavity.

Skin

Color

The color of the skin can be observed immediately, and pronounced variations in skin color can provide useful information.

Pallor may be a constitutional trait or a sign of a transitory epiphenomena of anxiety related to the situation and reflecting superficial vasospasm; if associated with concomitant mucosal pallor and pallor of the palms of the hands and the nail beds, pallor could indicate a state of anemia that should be confirmed by laboratory and other investigations.

Yellow skin and sclera may be the signs of bilirubin deposits associated with a liver or biliary tree disease, or a hematologic disease with hemolysis. A frequently observed benign situation is the so-called Gilbert jaundice that causes light jaundice (coloration of the sclera only) in the absence of hepatic or hematologic disease.

A yellowish coloration of the skin may result from chronic renal deficiency because of the retention of chromogens of urinary origin. In rare cases, deposits of carotene may be seen, often on the face, the palms of the hands, and the soles of the feet, in patients affected by hypothyroidism, hypopituitarism, or

■ Assessment of the Patient's General Health

diabetes, as well as in vegetarians who have a diet very rich in fruit and vegetables containing carotene.

A gray-bronze skin tone may be observed in those with hemochromatosis. This is a metabolic disease characterized by anomalous absorption and consequent accumulation of iron in the parenchyma (liver, pancreas, heart, skin, joints, and testicles); during the terminal phase, this condition can lead to cirrhosis of the liver, diabetes, and cardiac insufficiency.

Marked bronzing of the skin, if not explained as the result of exposure to sunlight or of a constitutional factor, must lead the clinician to suspect chronic hypocortisolemia. Addison disease is characterized by the destruction of the adrenal glands with consequent insufficient hormonal production of glucocorticoids and mineralocorticoids. Clinically, it is manifested by debility, anorexia, nausea and vomiting, hypotension, and often hypoglycemic crises. The skin coloration results from a compensating increase of corticotropin (ACTH) that also has a melanogenic activity. The recognition of chronic hypoadrenalism is important because of the stress associated with orodental interventions and possible complications that can trigger crises of acute adrenal insufficiency in such patients.

A bluish color of the skin and mucosa (cyanosis) is correlated with an increase of deoxygenated hemoglobin (> 4 g/dL). Cyanosis must always be referred for investigation of oxygen deficiency caused by pulmonary, cardiac, or hematologic disease. Light cyanosis limited to the lips and ungual bed can be observed in anxious patients who have vasoconstriction and venous capillary stasis, which slow the flow of blood to the skin with consequent transfer of oxygen to the tissues. The cyanosis may also be accompanied by a reddish purple coloration when the patient has an elevated number of red globules, as in the case of polyglobulia corresponding to respiratory insufficiency or polycythemia vera.

Reddening of the exposed areas is correlated with greater visibility of oxygenated hemoglobin and may be observed in patients with fever, patients who have consumed alcohol, patients who have local inflammation, or patients who simply have emotive vasodilation.

Lesions

Serious skin lesions that have significance as an indication of internal problems are spider angiomas or *spider nevi*, petechial lesions, and ecchymoses.

Spider nevi are characterized by fine radial branching from a central arteriole skin lesion; these are often observed on the face, the neck, or the upper trunk in patients with chronic hepatitis, particularly that caused by alcohol. Such observations indicate chronic liver diseases that may be associated with deficient coagulation.

Petechial lesions are small (1- to 2-mm) red or purple marks on the skin or mucosa that are not raised and do not disappear if compressed; they are characteristic of disorders of the number or function of the platelets or of small-vessel vasculitis. Hematologic, hepatic, and rheumatologic diseases are associated with these observations. If also correlated with vasculitis, the lesions may be slightly raised. Multiple petechial lesions may be aggregated in extensive purpuric skin lesions.

Ecchymoses (bruises) may be colored red-bluish-greenish. They are more extensive than petechial lesions, irregular in shape or polycyclic, and correspond to bleeding under the skin; if they are spontaneous, and not of traumatic origin, they may indicate deficiency of serum blood coagulation factors.

Inspection of the skin and especially the scalp might also reveal alterations that may be neoplastic, such as basalioma or melanoma, for which the patient should be encouraged to visit a dermatologist.

Hands

The most frequently seen alterations of the hands are degenerative joint diseases. Deformation of the distal interphalangeal articulations are characteristic of such degenerative arthropathy; gout-related tophi may also be present near articulations of the hand with symptoms similar to arthritis.

Afflictions of the proximal interphalangeal articulations and the metacarpal-phalangeal with swelling and deviation from the normal axis are typical of rheumatoid arthritis. Other forms of inflammatory rheumatism that may affect the joints of the hands and are similar to rheumatoid arthritis are psoriatic arthritis, arthritis associated with inflammatory intestinal diseases, and systemic lupus erythematosus.

Clubbed deformation of the distal parts of the fingers, similar to a drumstick, and fingernails the size of watch crystals are often associated with cardiopulmonary diseases.

Alterations of the fingernails may also be an indication of internal diseases: iron deficiency (koilonychia), bacterial endocarditis (hemorrhage in the nailbeds), psoriasis (pinhead-shaped depressions).

Oral cavity

Other objective signs in the oral cavity may also be indicative of systemic disease (Table 1-1).

Halitosis

Although halitosis is more often than not idiopathic, once oral and otorhinolaryngologic diseases are excluded, halitosis may indicate the presence of certain diseases if there are particular characteristics: a fishy odor (feter hepaticus of hyperammone-mia), a urine smell (chronic renal insufficiency), a sweet fruity smell (diabetic ketoacidosis), or a smell of putrefication (divertic-

Table 1–1 Lesions and oral diseases that may have links to other medical conditions

Cause	Type and site of lesion	Clinical notes/observations
Candidiasis	In any part of the mouth; pseudomembranous with white staining; erythematic; leukoplakia of the tongue; angular cheilitis	Responds to antimicrobics
Recurrent aphthous ulcers	Small painful ulcers, single or in groups, with erythematous borders; in any part of the mouth	Improve with topical steroids and tetracycline suspension
Traumatic ulcers	Small ulcerations with red edges in an area that is subject to possible trauma	
Lichen planus	White striae on the oral mucosa	Cutaneous lesions (violet nodules) on areas subject to friction
Acute necrotizing ulcerative gingivitis (ANUG)	Necrosis and bleeding ulcerations of the gingival papillae	Fever, halitosis, and lymphadenitis
Primary herpetic infection (acute gingival stomatitis)	Vesicular ulceration of the lips and mucosa	Fever, halitosis, dysphagia, and lymphadenitis
Labial herpes simplex	Vesicles and then crusts; on the mucocutaneous junction and perioral area	
Intraoral herpes simplex	Small vesicles; on the palate and gingiva	
Herpes zoster	Linea, unilateral vesicles, and ulcers; on the gingiva, palate, tongue, and cheek	
Mononucleosis	Small ulcers, petechiae, and gingival bleeding; affects the oral mucosa	Pharyngitis, fever, and lymphadenitis
Papilloma virus	Papillary lesions with keratinized apices; on the oral mucosa and skin	
Herpangina (coxsackievirus A, coxsackievirus B, and echovirus)	Vesicles and superficial ulcers; on the oral mucosa, pharynx, and tongue	Fever and sore throat
Coxsackievirus A: hand, foot, and mouth disease	Vesicles and superficial ulcers; on the oral mucosa, pharynx, palms, and soles	Fever and headache
Tuberculosis	Solitary ulcers with an undermined edge on the tongue, soft palate, and tonsils	
Actinomycosis	Swelling of the face, neck, and floor of the mouth	Exudation similar to pus but with "sulfur granules"
Histoplasmosis	Small nodules that can be ulcerated; in any part of the oral cavity	Dysphagia, dysphonia, and fever
Primary HIV infection	Oropharyngeal ulcers and acute gingivitis; on the palate, gingiva, and pharynx	Fever and lymphadenitis
Primary syphilis	Papules that evolve into nonpainful ulcers with a hardened border	Unilateral lymphadenitis; serologically positive after 3 weeks
Secondary syphilis	Maculopapillary lesions with central ulceration and gray exudate on the oral mucosa; duration of 1 year	Fever, malaise, and pharyngalgia
Tertiary syphilis	Luetic gumma on the tongue and palate with lingual papillary atrophy	Severe destruction of the palate
Congenital syphilis	Staining and fissuring of the oral and perioral tissues	Irreversible lesions of the teeth
Gonorrhea	Diffuse glossitis with ulcerations; viscous and fetid saliva	Lymphadenitis and fever
Mucomembranous pemphigoid	Painful vesicles or boil with erythematous peripheral areas of the mouth	Can be found on other mucosa (eyes, urethra, vagina, and rectum)
Erythema multiforme (Stevens-Johnson syndrome)	Boils surrounded by erythematous halos; hemorrhagic crusts on the lips	Lesions on the hands and feet; can be severe and fatal
Pemphigus vulgaris	Boils and ulceration of the oral mucosa	Cutaneous lesions also present
Behçet syndrome	Multiple aphthous ulcerations in the oral cavity	Eye, genital, intestinal, and neurologic lesions

ular disease of the esophagus, bronchiectasis, or lung abscess). Intense halitosis may also be associated with cigarette smoking.

Pigmentation

Coloration may also be indicative of the presence of some disease, whether represented by accumulation of melanin in the form of small marks (melanotic dyspigmentation of the oral cavity) or diffuse pigmentation of the whole oral mucosa (in some races also associated with smoking). Brown or blue-black stains may be observed on the buccal mucosa in some endocrinologic diseases (Addison disease); accumulation of dark brown pigment in any buccal area associated with coloration around the lips, the nose, and the eyes is characteristic of gastrointestinal diseases (Peutz-Jeghers syndrome with multiple hamartomatous polyps of the enteric tract); nonspecific pigmentation of the buccal mucosa or perigingival area may be associated with toxicity (lead, mercury, or bismuth). Submucosal yellowish stains on the lips and in the mouth may be correlated with hyperplasia of sebaceous glands (Fordyce disease). Gray, brown, or black pigmentation has been described as associated with use of antimalarial drugs, estroprogestinic drugs, and sedatives and disappears on suspension of the drug. Amalgam tattoos (also visible on radiographs) may be found on the gingival mucosa near teeth with amalgam restorations. Nevi and melanomas may also be found on the buccal mucosa.

Nonpigmented lesions (white)

Nonpigmented or white lesions are possible with various pathologic conditions: smokers' leukoplakia, nicotine stomatitis, lichen planus, white sponge nevi, friction keratosis, leukoplakia villosa, chemical burns, and candidosis.

Alterations of the tongue

Any changes in the tongue must be noted: Macroglossia is typically related to endocrine diseases (hypothyroidism or acromegaly) but also to metabolic diseases and to neoplasms (hemangioma and lymphoma of the tongue). Atrophy of the oropharyngeal mucosa and the lingual papillae are often a sign of Plummer-Vinson syndrome and iron deficiency; pernicious anemia and vitamin B₁₂ deficiency lead to similar mucosal conditions. Other vitamin B deficiencies may be suspected when alterations such as reddening or ulcerations of the oral mucosa or the tongue, swelling of the tongue, and angular cheilosis are seen. Candidiasis may also be responsible for hypertrophy of the posterior median area of the tongue (median rhomboid glossitis).

Periodontal alterations

Changes in the patient's periodontium require that the clinician investigate the possibility of unrecognized and untreated diabetes.

Gingival hyperplasia

Overgrowth may be secondary to therapy with phenytoin, used for the treatment of some types of epilepsy, and nifedipine, used for the treatment of ischemic cardiopathy and hypertension. Hemorrhagic, hyperplastic, and necrotizing alternations are frequently associated with monocytic leukemia and agranulocytosis.

Recurrent aphthous ulcerations associated with eye inflammation

These conditions may evoke a suspicion of Behçet syndrome, a multisystemic disease of unknown etiology mainly affecting the articulations, eyes, nervous system, gastroenteric tract, skin, and vascular system.

Xerostomia

Dry mouth can be observed in patients who are simply nervous or in those who are using drugs or medicines such as antihistamines, tricyclic antidepressants, and antipsychotics. The sicca syndrome characterizes Sjögren syndrome, an immunologic disorder in which the lacrimal and salivary glands are severely affected and other systemic disorders are present. Atrophy of the salivary glands can also be a secondary consequence of radiotherapy of the tissues of the neck.

Neck

Inspection and palpitation of the neck provide information regarding the dimension and macroscopic structure of several organ and tissues: the thyroid, the lymph nodes, the salivary glands, and the cervical vessels.

The thyroid is not usually visible but is normally palpable; palpation is best performed from a posterior approach. Uniform, symmetric enlargement of both lobes and the isthmus can be encountered in Basedow disease, while irregular or asymmetric enlargement is typical of the simple goiter. Circumscribed nodes may lead to a suspicion of a partial goiter or, if the size is greatly enlarged, to the presence of a neoplasm.

The cervicofacial lymph nodes are subdivided as follows:

- Preauricular
- Postauricular
- Occipital
- Tonsillar
- Submaxillary
- Submental
- Superficial cervical
- Posterior cervical chain
- Deep cervical chain
- Supraclavicular

Palpation of the lymph nodes is important when the patient has inflammation.

The palpation of the carotid artery is made with the second and third fingers along the border of the sternomastoid muscle. It is necessary to check the pulse and symmetry. Aneurysmal enlargement of the carotid artery can be observed in elderly patients.

Lungs (essential signs)

The evaluation of the pulmonary area is made in the following order: inspection, palpation, percussion, and auscultation. Alterations of the thoracic cage (kyphosis, kyphoscoliosis, or barrel thorax from emphysema), surgical scars, and anomalies of the respiratory muscles can be noted during the inspection.

Palpitation essentially checks for asymmetry of the tactile vocal fremitus; the examiners can provoke this by asking the patient to say "ninety-nine" while feeling the vibrations in the thorax with the palm of the hand. Absence or reduction of the tactile vocal fremitus is an indicative of bronchial obstruction, pneumothorax, or pleural effusion.

Percussion checks the resonance of the pulmonary area under the finger of the examiner. Flatness and pulmonary dullness are indicative of reduction of air (thickening of the parenchyma or pleural effusion), while hyperresonance and tympany are observable when air is excessive (emphysema or pneumothorax).

Auscultation enables the flow of air to be heard as it passes into the bronchial tubes and fills the lung alveoli. This technique reveals bronchial, alveolar, and pleural (rubbing) noises of the lungs during inspiration and expiration.

Heart (essential signs)

The examination of the heart proceeds via inspection, palpation, and auscultation. During inspection abnormal pulses are sought. Furthermore, it is important to evaluate whether abnormal pulses are present at the cervical level (carotid and jugular veins).

Palpation allows better localization of the apical impulse, which often is only palpable and not visible, and of eventual cardiac thrills that are suggestive of valvular disease.

Auscultation allows the heart sounds, rhythm, and pauses to be characterized; the presence and variations of extra sounds, murmurs, and other potentially pathologic noises may be heard.

For basic control of cardiac conditions, the following parameters are most important: location of the apical impulse, rhythm, frequency, and the presence of murmurs. When anomalies of these parameters are recognized, the patient should be referred to a specialist.

Abdomen (essential signs)

The abdomen is examined through inspection, auscultation, palpation, and percussion. Inspection looks at the general form as well as the presence of hernia, laparocoele, surgical scars, abnormal masses, and superficial vessels.

Auscultation is only used for the evaluation of intestinal peristalsis. Murmurs originating from abdominal vessels can be detected.

Palpation, initially superficial and successively deeper, can reveal any abdominal pain and define the site where it occurs. Palpation can also be used for examining organs of the hypochondrium (liver, spleen, and kidneys) and any pathologic mass or abnormal pulsation.

Percussion is principally used for evaluating the peritoneal effusion (ascites) and the sizes of the liver and spleen.

Laboratory examinations

Technical evolution in the practice of medicine now ensures that both laboratory and some instrumental examinations complement clinical observations.

While medical and technical specialists are needed to interpret the results of instrumental examinations, dental examiners should know the normal values of laboratory tests; such information is now usually indicated beside test results, facilitating understanding and interpretation of the results.

There is no need to dwell on the interpretation of the most common clinical laboratory tests, for which chemical and clinical textbooks are available¹⁻³; however, a brief overview of the serologic tests relative to viruses that might be transmitted during dental examination or treatment is presented in Table 1-2.

Communication with the patient's physicians

The information obtained from the medical history, objective examination, and laboratory tests, if any, may indicate that it is safe to proceed with dental treatment, with appropriate precautions. It is also possible that the collection of information has revealed certain specific problems: a suspicion of a disease not yet known to the patient, aggravation of an already recognized disease, or concomitant therapeutic problems. In such occurrences, it is wise to contact the patient's general medical practitioner. The patient is often advised to contact the general physician personally, or the generalist is contacted by the dentist, often by telephone.

These methods are informal, have no medicolegal value, and may be a source of errors. It is strongly advised that the contact be formalized in a brief but complete written communication

Table 1–2 Laboratory examinations for infectious diseases

Disease	Significance
<i>Hepatitis B virus (HBV)</i>	
HBsAg	Hepatitis B surface antigens; patient is infective
HBeAg	Hepatitis B e antigen; patient is highly infective
HBV DNA	DNA viral; patient is infective (also with "negative" values if the test is of low sensitivity (as for hybridization)
Anti-HBc	Antibodies for "core" antigens; aspecific significance, present in all situations after exposure to HBV (except after vaccination)
Anti-Hbe	Anti-e antibodies; previous infectiveness with exceptions (mutated virus); does not exclude infectivity
Anti-HBc IgM	Antibodies IgM; recent acute infection or recrudescence; patient is infective for anticore
Anti-HBs	Antibodies for surface antigens; previous infections cured; infectiveness ceased
<i>Hepatitis C virus (HCV)</i>	
Anti-HCV (ELISA)	Anti-HCV antibodies; patient is infective (except in special cases)
Anti-HCV (RIBA)	Anti-HCV antibodies; patient is infective (except in special cases)
HCV RNA qualitative	RNA viral +/- ; patient is infective (after repeated negative results and spontaneous cure or treatment with antivirals, which reduce infectiveness)
HCV RNA quantitative	RNA viral quantitative in mEq/mL or copies/million; examination has low sensitivity; negative results do not exclude the presence of the virus
<i>Hepatitis delta virus (HDV)</i>	
Anti-HDV	Antibodies to delta antigens; patient is infective
HDV RNA	RNA viral; patient is infective
<i>Hepatitis A virus (HAV)</i>	
Anti-HAV IgM	IgM antibodies for HAV antigens; patient is infective
Anti-HAV IgG	IgG antibodies for HAV antigen; previous infection
<i>Cytomegalovirus (CMV)</i>	
Anti-CMV IgM	IgM antibodies for CMV antigen; patient is probably infective from recent or active infection
Anti-CMV IgG	IgG antibodies for CMV antigen; if anti-CMV IgM negative and level not increasing, previous infection
<i>Epstein-Barr virus (EBV)</i>	
Anti-VCA IgM	Acute infection
Anti-VCA IgG	Previous infection or reinfection
<i>Human immunodeficiency virus (HIV)</i>	
Anti-HIV-1/HIV-2 (ELISA)	Probable infection
Anti-HIV-1/HIV-2 (western blot)	Confirmed infection
HIV RNA (PCR or DNA)	Confirmed infection
Ag = antigen; IgM = immunoglobulin M; ELISA = enzyme-linked immunosorbent assay; RIBA = recombinant immunoblot assay; IgG = immunoglobulin G; VCA = viral capsid antigen; PCR = polymerase chain reaction.	

between the dentist and the patient's generalist. Telephone contact may also be useful to obtain and provide immediate information; however, it is always advisable to follow up this contact with a written communication.

Internal Medical Problems

The following pages contain practical advice regarding the conduct of the dental clinician when confronted with a patient who has internal medical problems that are already recognized or being treated, for which particular precautions are needed before, during, or after dental treatment. The specific internal medical problems were chosen from among the many that could be addressed for being severe and complex or very common. A basic knowledge of these diseases and treatments is presumed; for updates and further information, consultation of specialized textbooks is recommended.

Cardiac problems

Organic cardiac murmur, valvular cardiopathy, congenital cardiopathy, and valvular prosthesis

Possible problems:

- Bacterial endocarditis
- Infection of the valvular prosthesis
- Pharmacologic anticoagulation

Prevention of complications:

- Communicate with the patient's physician to obtain a correct assessment of the cardiac murmur.
- Prevent hemorrhage in patients taking anticoagulant drugs. Stop the dicumarolic drugs 5 to 7 days before the intervention and check the international normalized ratio (INR) after 2 days; when the INR value is approximately 2.0, begin low-molecular heparin injections. The heparin must be stopped 12 hours before the intervention and reintroduced 12 hours after treatment. The dicumarolic drugs may be then reintroduced and the heparin definitively stopped when the INR is greater than 2.0.
- Administer 2 g of amoxicillin (50 mg/kg for children) as a single injection 1 hour before the procedure.

Note: In patients allergic to penicillin, administer 600 mg of clindamycin (or 500 mg clarithromycin or azithromycin, 2 g cephalexin or cefadroxil) as a single injection 1 hour before the procedure.

Arterial hypertension

Possible problems:

- Increased local bleeding
- Angina pectoris, myocardial infarct, and cerebrovascular accidents from hypertensive crises caused by stress, anxiety, and adrenergic drugs

Prevention of complications:

- Communicate with the patient's physician if the patient's blood pressure is not properly under control; do not intervene if diastolic pressure is greater than 115 mm Hg.
- Ensure adequate local hemostasis.
- Reduce the patient's stress and anxiety: Provide a morning appointment, a short wait in the waiting room, reassurance, and a peaceful environment; if necessary, administer diazepam in the morning; if necessary, administer an extra dose of nitro derivative before the intervention; administer effective anesthesia, without or with a very small dose of epinephrine (1:100,000), ensuring that the dose is not administered in a blood vessel and without exceeding three doses.
- Avoid sudden change in patient positioning.
- Avoid use of topical vasoconstrictors.

Note: Questions about the usual arterial pressure, the existence of hypertension, and the possible drugs used for treatment always should be asked when the medical history is taken.

In case of hypertensive crisis (diastolic pressure greater than 130 mm Hg), administer nifedipine tablets, 10 mg; clonidine tablets, 0.150 mg; or captopril tablets, 25 mg:

- Nifedipine: 1 to 2 tablets chewed with deglutition of the liquid content; effect in 5 to 15 minutes, variable, sometimes excessive
- Clonidine: 1 to 2 tablets; effect in 30 minutes to 2 hours; sedation, rebound hypertension at the end of the effect
- Captopril: 0.25 to 2 tablets; effect in 15 minutes; not to be used if the patient is pregnant; excessive response if it is taken by a patient undergoing diuretic therapy

Ischemic cardiopathy (asymptomatic, in therapy, and stabilized)

Possible problems:

- Angina crisis, infarct, and/or arrhythmia (even to a life-threatening level) provoked by anxiety and stress
- Bleeding in patients undergoing therapy with antiplatelet or anticoagulant drugs

■ Assessment of the Patient's General Health

- Electric disorder and endocarditis (rare) among pacemaker recipients

Prevention of complications:

- Obtain a complete patient history (general history and pharmacologic history).
- Communicate with the patient's physician if the patient is not stable under the ischemic profile or if the doses of anticoagulants have to be temporarily changed.
- Reduce the patient's stress and anxiety: Provide a morning appointment, a short wait in the waiting room, reassurance, and a peaceful environment; if necessary, administer diazepam in the morning; if necessary, administer an extra dose of nitro derivative before intervention; administer effective anesthesia, without or with a very small dose of epinephrine (1:100,000), ensuring that the dose is not administered in a blood vessel and without exceeding three doses.
- Postpone procedures for at least 6 months after a cardiac infarction if they are not absolutely necessary.
- Do not treat patients with coronary bypass until at least 2 weeks after the operation.

Note: A question about the cardiologic ischemic background of the patient always must be included within even a simplified approach to history taking.

In case of angina pectoris crisis:

- Seat the patient.
- Administer 0.3 mg of nitroglycerin, 1 to 2 tablets, chewed and then sucked without swallowing, or nitroglycerin spray (2 puffs under the tongue).
- Effect in 1 to 5 minutes, usually associated with headache; if nothing happens, the medicine can be taken twice after 5 minutes. Note that nitroglycerin tablets deteriorate a few months after opening of the container.
- If the pain persists for more than 20 minutes, suspect myocardial infarction and ask emergency services for an immediate evaluation in the hospital.

Cardiac insufficiency

Possible problems:

- Increased risk of cardiac failure as a result of treatment
- Arrhythmias
- Angina or infarction
- Cerebrovascular and peripheral vascular accidents
- Collateral effects of drugs (orthostatic hypotension induced by diuretics and vasodilators; arrhythmias induced by digital-

is and hypokalemia; gastrointestinal problems induced by digitalis; bleeding caused by anticoagulants)

- Local infections

Prevention of complications:

- Treat only patients whose disease is fully compensated.
- Refer the patient again to his or her physician to improve compensation; request precise information on the cause, hemodynamic situation, and current therapy.
- Reduce the patient's stress and anxiety: Provide a morning appointment, a short wait in the waiting room, reassurance, and a peaceful environment; if necessary, administer diazepam in the morning; if necessary, administer an extra dose of nitro derivative before intervention; administer effective anesthesia, without or with a very small dose of epinephrine (1:100,000), ensuring that the dose is not administered in a blood vessel and without exceeding three doses.
- If possible, have the patient sit up straight.
- Arrange a temporary reduction of anticoagulants and ensure effective local hemostasis.
- Take steps to prevent local infection and provide early therapy for any local infection that does occur.

In case of acute failure with pulmonary edema:

- Seat the patient.
- Administer 100% oxygen via nasal prongs.
- Administer furosemide, 40 mg, intravenously.
- Administer morphine sulfate, 10 mg, diluted in 10 mL of saline; inject 2 mL slowly (2 mg of morphine sulfate); repeat after 5 minutes if the situation does not improve; maximal dosage is 10 mg.
- If hypertension coexists, administer nifedipine cps, 10 mg, in two doses, to be chewed and contents to be swallowed.
- If angina coexists, administer 0.3-mg tablets of nitroglycerin, in two doses, to be chewed.
- If bronchospasm coexists, inject aminophylline, 240 mg, very slowly intravenously.
- Send the patient to the nearest hospital.

Cardiac transplant recipients

Possible problems:

- Infections facilitated by steroidal therapy and cyclosporin
- Hemorrhagic diathesis resulting from anticoagulants

Prevention of complications:

- If possible, definitively treat all existing dental problems before the transplantation.

- Provide antibiotic prophylaxis; it is considered an empirical but prudent measure. Use the regimen recommended for patients with valvular cardiopathy and valvular prostheses.
- Communicate with the patient's physician to arrange reduction of anticoagulant therapy.
- Ensure effective local hemostasis.
- Administer an extra dose of steroids only for important and complex operations (see the discussion of chronic suprarenal failure and chronic steroidal therapy). If there was a preexisting ischemic cardiopathy, see the advice in the pertinent section.
- Start an effective program of dental prophylaxis.

Arrhythmias

Possible problems:

- Arrhythmias caused by stress and anxiety
- Arrhythmias induced by epinephrine
- Electromagnetic interferences with the proper function of pacemakers induced by electrical equipment
- Hemorrhage caused by use of anticoagulants

Prevention of complications:

- Identify patients at risk (ischemic cardiopathy, chronic respiratory failure, and rheumatic cardiopathy) through the history, pharmacologic history, and physical examination.
- Communicate with the patient's physician for uncertain cases or to arrange reduction of anticoagulants.
- Reduce the patient's stress and anxiety: Provide a morning appointment, a short wait in the waiting room, reassurance, and a peaceful environment; if necessary, administer diazepam in the morning; if necessary, administer an extra dose of nitro derivative before the intervention; administer effective anesthesia, without or with a very small dose of epinephrine (1:100,000), ensuring that the dose is not administered in a blood vessel and without exceeding three doses.
- Use extreme caution in using electrical equipment near patients with a pacemaker.
- Administer antibiotic prophylaxis. Use the regimen recommended for patients with valvular cardiopathy and valvular prostheses.

Note: If an unknown and unclassified cardiac arrhythmia is found, the patient must have an electrocardiogram before any dental procedure is performed.

Cardiac arrest (basic cardiopulmonary resuscitation)

- Ask for help from others, directing them to call emergency services and make themselves useful.
- Make the patient lie on his or her back on a hard surface.
- Extend the patient's neck, bringing back the head and raising the jaw.
- Free the airway from any objects, prosthesis, secretion, or vomit.
- Observe and listen to determine if the patient is breathing.
- If the breath is absent, perform two mouth-to-mouth resuscitations, slowly (2 seconds for each resuscitation); the patient's nose must be held with a hand and the effectiveness of the action must be checked by observing the thoracic expansion. To improve the efficiency and the safety of the action, it is important to use a Mayo cannula, a mask for mouth-to-mouth resuscitation, a bag-valve mask, and a laryngeal mask.
- Take 5 to 15 seconds to check the carotid pulse.
- If the pulse is absent, perform 15 chest compressions (on the lower third of the sternum with a range in depth of 4 to 5 cm).
- Continue the resuscitation by alternating 2 respirations and 15 chest compressions.
- If there are two rescuers, one performs the respiration and one performs the chest compression, using the aforementioned rhythm.
- After endotracheal intubation, the rhythm is 5 compressions and 1 respiration without interruption of the compressions.
- The actions of advanced resuscitation (tracheal intubation, defibrillation, and intravenous injections) are performed at the arrival of the emergency services team. (If a third person who is able to find a venous line is present while two people perform the resuscitation as described, he or she looks for the venous line with an 16- to 18-gauge needle/catheter and keeps it open with an infusion of saline.)

Hepatic problems

Liver cirrhosis (viral, alcoholic, hemochromatosis, autoimmune, or cryptogenetic)

Possible problems:

- Hemorrhagic diathesis
- Reduced metabolism of some drugs
- Possibility that the patient is a carrier of hepatitis C virus (HCV), hepatitis B virus (HBV), hepatitis delta virus (HDV), or human immunodeficiency virus (HIV)

Prevention of complications:

- Identify the problem (history).
- Assess the prothrombin time (PT), partial thromboplastin time (PTT), fibrinogen, antithrombin III, fibrinogen split products, and blood platelet count.
- In case of disordered values (platelets < 50,000, PT < 50 seconds, and PTT > 40 seconds), consult with the patient's specialist to select a regimen for hemorrhage prevention.
- Avoid or reduce the dose of drugs metabolized by the liver or known to be possible inducers of hepatotoxicity.
- Assess the levels of hepatitis B surface antigen (HBsAg), hepatitis B e antigen (HBeAg), hepatitis delta antibody (anti-delta), hepatitis B surface antibody (anti-HBs), hepatitis B e antibody (anti-HBe), and hepatitis C antibody (anti-HCV).
- Follow strict anti-infectious precautions for the dentist and the dental team.

The following drugs commonly used in dentistry have a predominantly hepatic metabolism:

- Lidocaine and mepivacaine
- Tetracycline and ampicillin
- Acetylsalicylic acid and acetaminophen
- Diazepam and barbiturates

Possible HCV, HBV, or HIV carrier

Possible problems:

- Infection of the dentist and dental team members

Prevention of complications:

- Test the patient for HCV, HBV, HDV, and HIV.
- In case of positivity that was previously unknown, communicate with the patient's physician.
- Follow strict anti-infective precautions.

The following variables increase an individual's risk of carrying hepatic viruses:

- Employment in health care (eg, psychiatric nurses, nurses, laboratory technicians, people in charge of transfusion centers, surgeons, and dentists)
- Hospitalization in a psychiatric environment
- Periodic hemodialysis
- Receipt of an organ transplant
- Drug addiction
- Hemophilia
- Having tattoos or piercings
- High-risk sexual activity
- Being related to a HBsAg carrier
- Living in a high-risk geographic area (eg, Africa, Asia, and South America)

Epidemiologic data

In Italy the prevalence of HBsAg carriers varies from 2% to 7%, with peaks in the southern regions. The possibility of contracting hepatitis B has been widely reduced in recent years since the introduction of vaccination and decades of blood donor screening.

In case of accidental exposure, prophylaxis with a vaccine is efficacious in 95% of cases; check for existing seroconversion and the anti-HBs level (minimum protective level 10 IU/mL). Serum prophylaxis with specific immunoglobulins (HBIG), to be used for patients who are not immunized, is efficacious in 75% of cases and it has to be conducted within 12 hours after accidental exposure.

If the dentist or some other member of the dental team is an HBsAg carrier, it is always necessary to complete anti-infective prophylaxis toward the patient.

Currently, hepatitis C transmission, for which there is neither a vaccine nor specific immunoglobulins, is still worrisome. Its prevalence among the general population is directly proportional with age, with peaks of 18% for subjects older than 65 years.

Anti-infective precautions

- Wear gloves to avoid contact with blood, saliva, mucosa, and infected instruments.
- Wear a mask and glasses to avoid jets of saliva and spurts of blood.
- Use disposable gowns.
- Protect objects that are difficult to disinfect (lights, radiologic instruments, etc).
- Reduce to a minimum aerosol spray from air insufflated in the oral cavity.
- Wash hands thoroughly before seeing the next patient.
- Use sharp and pointed instruments with caution. (All disposable instruments must be put in puncture-proof containers.)
- Perform appropriate sterilization of the instruments after each patient.
- Disinfect the contact surfaces after each patient.

Hepatic transplant recipients

Possible problems:

- Hypertension (caused by steroids)
- Concomitance of chronic renal failure (caused by cyclosporin)
- Tendency toward infections (caused by immunosuppressive drugs)
- Delayed wound healing (caused by steroids)
- Difficulty in coping with stress (caused by steroids)
- Possibility of being a carrier of HCV, HBV, or HDV

Prevention of complications:

- Work in close collaboration with the patient's physician.
- Administer antibiotic prophylaxis and vigorous therapy for infections.
- Follow a scrupulous surgical technique.
- Avoid the use of drugs with potential hepatotoxicity or nephrotoxicity.
- Increase the steroid dosage (see the discussion of chronic renal failure and chronic therapy with steroids).
- Monitor and stabilize the arterial pressure.

Pulmonary problems

Chronic obstructive pulmonary disease (COPD)

Possible problems:

- Temporary worsening of the respiratory problems

Prevention of complications:

- Have the patient sit in an upright position.
- Do not use bilateral or palatal mandibular anesthesia blocks.
- Do not use rubber dam.
- Do not use drugs that inhibit the respiratory center or increase the stickiness of secretions (barbiturates, narcotics, antihistamines, and anticholinergics).
- If the patient is receiving chronic steroid therapy, when necessary, increase the dosage.
- Provide ventilation with a low flow of oxygen.
- Consider the possibility of performing the procedure in a hospital.

Bronchial asthma

Possible problems:

- Outbreak of an asthmatic crisis

Prevention of complications:

- Identify the problem (history).
- Obtain specific information about the type of asthma (whether allergic or caused by drugs; provoking factors; and drugs efficacious during an acute attack).
- Avoid provoking factors.
- Do not use acetylsalicylic acid, nonsteroidal anti-inflammatory drugs, steroidal drugs, narcotic sedatives, erythromycin (if the patient takes theophyllin derivatives), or anesthetics containing sulfites.
- Provide a calm environment.
- Provide premedication with anxiolytics.

- Have β -stimulant spray ready to use (phenoterol or albuterol), as well as adrenalin, injectable steroids, and aminophylline.
- Patients who are undergoing chronic therapy with steroids can ask their physician for an increase of the dosage.

Note: During an acute attack, the drug to be used first is the inhaled β -stimulant, then the intravenous steroids; aminophylline has to be considered the third choice. In case of an hyperacute attack, it is advisable to use one third of a vial of 1:1,000 adrenaline, or one half of a vial of terbutaline, administered subcutaneously, followed by aminophylline (240 mg, administered slowly through the intravenous route), and finally hydrocortisone (250 to 1,000 mg, administered intravenously). The steroids will take a few hours to start their effect.

Tuberculosis (active)

Possible problems:

- Infection of the dentist and the dental team

Prevention of complications:

- Provide treatment only if urgent and in a hospital with appropriate precautions (asepsis, protection of the team, low-speed drill, and minimal use of air jet).

Note: It is always advisable to ask questions about previous exposure to tuberculosis infection. Skin reactivity for tubercular antigens has a relevant clinical importance only if it proves a recent change from negative to positive; the skin reactivity itself is not the sign of infection but only of a previous contact with *Mycobacterium tuberculosis*. The result is considered as positive if the infiltrate (not only the rash) has a diameter greater than 10 mm at 48 and 72 hours after the intradermal injection of 5 units. An infiltrate between 5 and 9 mm is a doubtful positive.

Past and inactive tuberculosis does not represent an active clinical problem.

Neurologic problems

Cerebrovascular diseases

Possible problems:

- Local bleeding in patients undergoing antiplatelet or anticoagulant drug therapy
- Cerebrovascular accidents during or after the intervention

Prevention of complications:

- Identify the patient's condition through the general history and pharmacologic history.

■ Assessment of the Patient's General Health

- Assess blood pressure.
- Reduce or interrupt the anticoagulant therapy, but only by previous agreement with the patient's physician.
- Reduce stress and anxiety: Provide a morning appointment, a short wait in the waiting room, reassurance, and a peaceful environment; if necessary, administer diazepam in the morning; if necessary, administer an extra dose of nitro derivative before the intervention; administer effective anesthesia, without or with a very small dose of epinephrine (1:100,000), ensuring that the dose is not administered in a blood vessel and not exceeding three doses.

Epilepsy

Possible problems:

- Seizure during the procedure
- Gingival hyperplasia (phenytoin)
- Increased chance of bleeding (valproic acid)

Prevention of complications:

- Obtain an accurate history of the precipitating factors.
- Ensure good pharmacologic control; communicate with the patient's physician for further information.
- Be prepared to treat a generalized seizure.

In case of a general convulsive crisis:

- Protect the patient against accidental injury from surrounding objects.
- Put the patient on the floor in a prone position and with the head turned (security position to prevent "ab ingestis" phenomena).
- If the crisis does not stop spontaneously within a few minutes, administer diazepam (10 mg) intravenously.
- If the crisis is repeated in spite of the intravenous therapy, hospitalize the patient immediately.

Nephrologic problems

Advanced chronic renal failure

Possible problems:

- Arterial hypertension
- Hemorrhagic diathesis
- Chronic anemia
- Reduced metabolism of some drugs
- Possible renal toxicity of some drugs
- Reduced metabolism and excretion of drugs

Prevention of complications:

- Stabilize the blood pressure.
- Evaluate PT, PTT, platelets, and bleeding time.
- Assess the red blood cell count.
- Do not use drugs with potential renal toxicity or those mainly excreted through the kidney or appropriately adjust the doses of such drugs.

Advanced chronic renal failure (dialysis)

Possible problems:

- Arterial hypertension
- Hemorrhagic diathesis
- Chronic anemia
- Reduced metabolism of some drugs
- Infection of the artificial arteriovenous fistulous tract
- Possibility of being a carrier of HCV, HBV, HDV, or HIV

Prevention of complications:

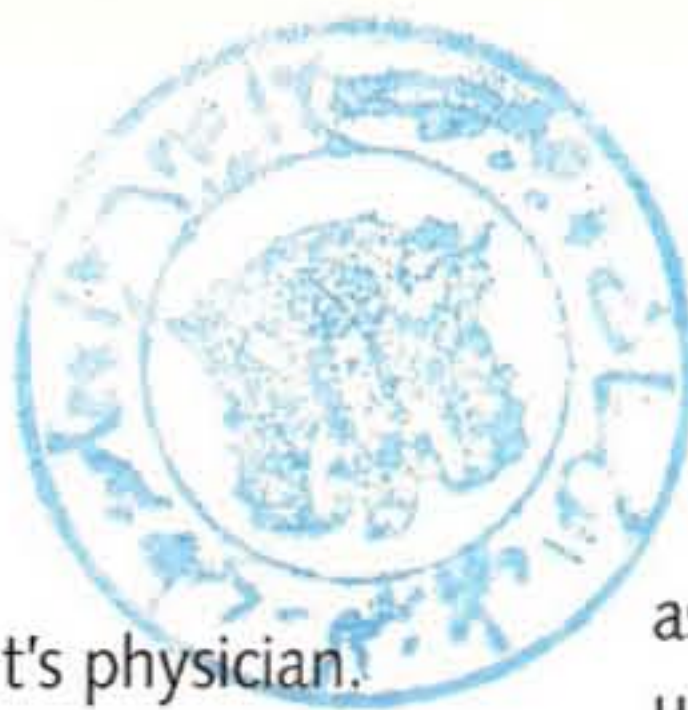
- Stabilize the blood pressure.
- Assess the PT, PTT, platelets, and bleeding time.
- Assess the red blood cell count.
- Do not use drugs with potential renal toxicity or those mainly excreted through the kidney, or adjust the dose of such drugs.
- Administer antibiotic prophylaxis. Use the regimen recommended for patients with valvular cardiopathy and valvular prostheses.
- Test the patient for HBsAg, anti-HBc, anti-HBs, anti-HCV, and anti-HIV.
- Avoid procedures in the 4 hours following the last dialysis session (heparin therapy).
- Collaborate with the physicians at the dialysis center.

Note: The problems of the patient undergoing peritoneal dialysis are similar to those explained in the previous section on advanced chronic renal failure.

Renal transplant recipients

Possible problems:

- Arterial hypertension (caused by steroids)
- Tendency toward infection (caused by immunosuppressive drugs)
- Delayed wound healing (caused by steroids)
- Difficulty coping with stress (caused by steroids)
- Possibility of being a carrier of HCV, HBV, HDV, or HIV



Prevention of complications:

- Work in close collaboration with the patient's physician.
- Administer antibiotic prophylaxis and ensure vigorous treatment of infections.
- Use a scrupulous surgical technique.
- Avoid the use of drugs with potential renal toxicity or those mainly excreted through the kidney.
- Test the patient for HBsAg, anti-HBc, anti-HBs, anti-HCV, and anti-HIV.
- Increase steroid dosage (see the section on chronic renal failure and chronic therapy with steroids).
- Measure and stabilize the blood pressure.

Metabolic and endocrinologic problems

Diabetes mellitus

Possible problems:

- Risks of hypoglycemia in a patient given insulin therapy or hypoglycemic oral agents
- Tendency toward skin and mucosal infections, especially if the diabetes is not adequately treated (abscess, candidiasis, and mucormycosis)
- Slow recovery of mucosal injuries
- Higher incidence of periodontal problems and oral ulcerations

Prevention of complications:

- Obtain a pharmacologic history.
- Use a quick screening test for blood and/or urine glucose.
- Communicate with the patient's physician when an unknown diabetic illness is suspected.
- Schedule a morning appointment.
- Do not instruct the patient to fast or interrupt antidiabetic drugs.
- Have the necessary materials to stop possible hypoglycemic crises available in the operatory (40% dextrose solution 2 vials, intravenously; glucagon 1 vial, intramuscularly; 5%, 10%, and 20% dextrose solution, 500 mL, with a setup for the infusion).
- In a patient with a severe local infection, it can be necessary to increase the insulin dosage, in consultation with the treating doctor.

Note: Because of the high frequency of diabetes in the population, it is always advisable to ask patients some questions about their family and personal history concerning this condition, even in a simplified history.

Diabetes is usually associated with pathologic situations such as ischemic cardiomyopathy; cerebrovascular disease; renal failure; and hypertension (see pertinent sections).

In the event of a hypoglycemic crisis (asthenia, sweat, sense of hunger, pallor, palpitations, psychotic behavior, motor deficit, coma, and convulsions):

- Perform a rapid check of the blood glucose level (not absolutely necessary and sometimes dangerous because it delays the treatment).
- If in doubt or when a check is impossible, treat the patient as for an emergency hypoglycemic crisis. (Possible hyperglycemia consequent to the treatment in a nonhypoglycemic patient is not dangerous; failure to correct a severe hypoglycemic crisis could be fatal or disabling.) Administer 40% dextrose solution, 20 mL, intravenously, followed by infusion of 5% or 10% dextrose solution; if venous access cannot be made, administer intramuscular glucagon, 1 vial. If or when the patient is able to swallow, give sugary drinks (tea or milk with a cookie). If the crisis recurs (a frequent event in patients who take oral antidiabetics), hospitalize the patient for observation.

Hyperthyroidism

Possible problems:

- Thyrotoxic crisis connected with the procedure due to stress, infection, or trauma
- Hypersensitivity to catecholamines
- High incidence of periodontal disease, caries, or osteoporosis

Prevention of complications:

- Identify the patient's condition through history, pharmacologic history, and objective tests.
- Communicate with the treating physician; if the results of the metabolic examination are not completely satisfactory, postpone the treatment and ask for laboratory tests (thyroid-stimulating hormone [TSH], free T3 [FT3], and free T4 [FT4]).
- Do not use or vasoconstrictors or use them carefully.
- Provide vigorous treatment of local infections.
- Identify thyrotoxic crisis (serious symptoms of hyperthyroidism such as tremor, sweating, tachycardia, fever, diarrhea, abdominal pains, delirium, and stupor).



Hypothyroidism

Possible problems:

- Myxedematous coma connected with the procedure because of stress, infection, or trauma
- Hypersensitivity to sedatives

Prevention of complications:

- Identify the patient's condition through the history, objective tests, laboratory tests, TSH, FT3, and FT4.
- Communicate with the patient's physician for uncertain cases, to verify thyroid compensation, and for information on possible concomitant ischemic cardiopathy.
- Identify the initial stage of the myxedematous coma (bradycardia, hypotension, hypothermia, slowdown of intellectual and motor activity, and epileptic crisis).
- Avoid the use of sedative drugs.

Adrenal failure and patients receiving chronic steroid therapy

Possible problems:

- Acute failure caused by stress, trauma, and infections
- Delayed recovery
- Tendency toward infection
- Hypertension caused by steroids

Prevention of complications:

- Identify the patient's condition (pharmacologic history).
- In patients who have taken steroids in doses equivalent to more than 20 mg/d prednisone for more than 1 month, communicate with the treating doctor to establish a medical therapeutic support strategy. Usually it is sufficient to double or triple the usual morning dose and operate about 1 hour later; the day after the procedure, the dose can still be doubled, especially if pain persists.
- In patients who take steroids in doses equivalent to less than 20 mg/d prednisone, or on alternating days, or at high dosages but for less than 1 month, or topically in a nonocclusive preparation and on limited skin surfaces, it is not necessary to administer extra steroids. However, the principle is that it is better to give unnecessary supplements than to risk an insufficiency crisis; high doses of steroids for few days are not dangerous (however, check the blood glucose level in diabetic patients).
- Do not provide supplements for patients who took steroids but stopped at least 12 months before.

- Conduct a posttreatment examination to assess healing and to look for infections.
- Treat infections.
- Check the patient's blood pressure.
- Identify suprarenal failure crisis (hypotension, asthenia, nausea and emesis, fever, and headache) and send the patient to the hospital after an injection of hydrocortisone (100 mg intravenously and 100 mg intramuscularly).

The following indicates the relative anti-inflammatory power (hydrocortisone = 1.0) of some commonly used steroids:

■ Hydrocortisone	1.0
■ Cortisone	0.8
■ Prednisone	4.0
■ Methylprednisolone	5.0
■ Triamcinolone	5.0
■ Betamethasone	25.0
■ Dexamethazone	35.0

Rheumatologic problems

Arthrosis

Possible problems:

- Bleeding, fostered by acetyl salicylic acid or other nonsteroidal anti-inflammatory drugs
- Rigidity and poor mobility

Prevention of complications:

- Reduce or interrupt the use of antirheumatic drugs in the week prior to the procedure.
- Assess bleeding time if interruption of medications is not possible.
- Ensure that the patient experiences a short waiting period and rapid treatment. Place the patient in a comfortable position with supports as needed.

Rheumatoid arthritis

Possible problems:

- Bleeding, fostered by acetyl salicylic acid or other nonsteroidal anti-inflammatory drugs
- Rigidity and poor mobility
- Risk of suprarenal failure in patients taking steroid therapy
- Risk of thrombocytopenia and leukopenia in patients treated with gold salts

Prevention of complications:

- Reduce or interrupt the use of acetyl salicylic acid or other nonsteroidal anti-inflammatory drugs in the week before the operation.
- Assess bleeding time.
- Ensure that the patient experiences a short waiting period and rapid treatment. Place the patient in a comfortable position.
- Confirm that there has been a recent platelet count for patients treated with gold salts.
- Communicate with the treating physician for patients being treated with steroids (see the section on adrenal failure).

Articular prosthesis recipients

Possible problems:

- Prosthesis infection caused by transient bacteremia from the dental operation site.

Prevention of complications:

- Administer antibiotic prophylaxis. (Use the regimen recommended for patients with valvular cardiopathy and valvular prostheses; certain orthopedic schools suggest other protocols that must be requested from the patient's orthopedic specialists.)

Hematologic problems

Congenital alterations of coagulation (hemophilia and von Willebrand disease)

Possible problems:

- Hemorrhage during or after the intervention

Prevention of complications:

- Identify the patient's condition (history: spontaneous hemorrhages, subsequent to previous dental extractions or surgical operations; physical examination; ecchymoses, hematomas, petechiae; laboratory tests: increased PTT accompanied by normal PT is found in hemophilia, and increased or normal PTT accompanied by increased bleeding time is found in von Willebrand disease).
- Communicate with the treating physician for a definitive diagnosis and to determine the antihemorrhagic therapeutic strategy to use (cryoprecipitate, frozen fresh plasma, prothrombin complex, or platelet concentrates).
- Ensure careful local hemostasis.

- Administer antibiotic prophylaxis to prevent local infections.
- Do not administer analgesics that affect platelet aggregation.

Note: A question regarding possible tendencies to spontaneous hemorrhage or to anomalous bleeding after medical interventions must always be asked, even in a simplified history.

Acquired alterations of coagulation (chronic hepatic diseases and malabsorption syndrome)

Possible problems:

- Hemorrhage during or after the operation

Prevention of complications:

- Identify the patient's condition (through the history and physical examination; laboratory tests indicate that PT is increased or reduced, whereas PTT is within normal limits; bleeding time is prolonged if the number of platelets is reduced).
- Communicate with the treating physician to obtain complete information and develop a therapeutic strategy (vitamin K, 10 mg, in the 2 days before the procedure).
- Ensure careful hemostasis.
- Do not administer acetyl salicylic acid or nonsteroidal anti-inflammatory drugs.
- Administer antibiotic prophylaxis to prevent local infections.

Note: A question regarding possible tendencies to spontaneous hemorrhages or to anomalous bleeding after medical interventions must always be asked, even in a simplified history.

Psychiatric problems

Psychiatric illnesses

Possible problems:

- Communication difficulties
- Side effects caused by psychiatric drugs: leukopenia, thrombocytopenia, hypotension, tachycardia, and apyralism (neuroleptic drugs); hypotension, tachycardia and other arrhythmias, and apyralism (tricyclic antidepressants and monoamine oxidase inhibitors); stomatitis, renal failure, and leukopenia (lithium).
- Interaction with psychiatric drugs from epinephrine and derivatives, sedatives, barbiturates, and atropine
- Uncooperative, aggressive personality

Prevention of complications:

- Identify the problem (through the history and pharmacologic history).
- Communicate with the patient's physician in the most serious cases.
- Approach the patient with empathy and simplicity; avoid confrontations of an authoritarian type.
- Schedule a morning appointment; ensure a short waiting period and rapid intervention.
- In some cases, the presence of a relative is advisable.

Drug addiction

Possible problems:

- Infection of the dentist and dental team members with HCV, HBV, HIV, or cytomegalovirus (patients who use morphine and derivatives)
- Arrhythmia and myocardial ischemia provoked by epinephrine if the patient has taken cocaine in the hours preceding treatment

Prevention of complications:

- Follow the precautions for carriers of HCV, HBV, and HIV, described in a previous section.
- Do not use epinephrine or other vasoconstrictors in patients who have taken cocaine in the last 6 hours.

Note: See the anti-infective prophylaxis in the section on HCV, HBV, and HIV carriers.

Other problems

Pregnancy and lactation

Possible problems:

- Risks for the fetus caused by drugs, radiation, and stress
- Drugs in the mother's milk
- Hypotension if the patient is in a horizontal posture at the end of the pregnancy

Prevention of complications:

Confirmed pregnancy:

- Avoid nonurgent procedures in the first and third trimesters.
- Avoid radiography in the first trimester.
- Avoid the administration of drugs such as tetracycline, streptomycin, diazepam, barbiturates, steroids, or other drugs for which safety during pregnancy is unknown.
- Avoid administration of codeine in the first trimester.

- Avoid administration of acetyl salicylic acid or nonsteroidal anti-inflammatory drugs in the third trimester.
- Avoid placing the patient in a horizontal position for extended periods in the terminal phase.

Uncertain or possible pregnancy:

- Avoid the administration of dangerous drugs (see above); it is best to avoid drugs in general.
- Avoid radiography unless strictly necessary; if radiography is necessary, use appropriate safety screens.
- Postpone the intervention until after immunologic confirmation of pregnancy.

Lactation:

- Schedule the appointment immediately after the lactation time.
- Do not administer tetracycline.
- Avoid the use of antibiotics that can modify the newborn's bacterial flora or cause sensitization.

Note: For female patients, a question regarding the date of the last menstrual period and the possibility of being pregnant must always be asked, even in a simplified history.

Syphilis

Possible problems:

- Infection of the dentist and dental team members by patients in an infectious condition

Prevention of complications:

- If there is a history of possible recent exposure to syphilis or there are objective signs of syphilis in progress at the oral mucosa level, postpone treatment and request serologic tests, both nonspecific (VDRL) and specific (treponema pallidum hemagglutination assay and fluorescent treponemal antibody absorption).
- If there is a history of previous syphilis, ask if appropriate therapy has been completed and if nonspecific negative serology has been confirmed.
- The VDRL test becomes negative after about 12 months in primary syphilis and after 24 months in the treated secondary stage; it cannot become negative in tertiary stages.
- In uncertain cases, request further serologic testing.
- Communicate with the treating physician if the patient needs treatment.

Note: A question about venereal diseases is compulsory even in a simplified medical history. Patients who answer affirmatively must be considered at risk for any sexually transmitted diseases (syphilis, gonorrhea, hepatitis B, acquired immunodeficiency

syndrome [AIDS], and genital herpes) that can be contagious for the dental team.

Radiotherapy (head and neck)

Possible problems:

- A greater incidence of mucosal inflammation, apyralism, ageusia, trismus, infections, hypersensitivity, and osteonecrosis

Prevention of complications:

- Treat definitively all dental, gingival, and osseous injuries and prepare the prosthetic attachment site before the beginning of radiotherapy.
- Treat with local fluoride.
- Prevent trismus with a bite block.
- Educate the patient for maximum dental hygiene.
- Plan regular, short-term recall examinations.
- Avoid extractions after radiotherapy, because of the tendency toward osteonecrosis.

Chemotherapy

Possible problems:

- Tendency toward bleeding caused by thrombocytopenia
- Tendency toward local infections caused by leukopenia

Prevention of complications:

- Treat definitively all dental, gingival, and osseous injuries and prepare the prosthetic attachment site before beginning chemotherapy.
- Extract any remaining primary teeth and gingival operculum before beginning chemotherapy.
- Educate the patient for maximum dental hygiene.
- Instruct the patient not to use a toothbrush during periods of leukopenia and thrombocytopenia; use soft pads for cleaning.
- Schedule frequent recall examinations.
- Provide early and vigorous treatment of infections after culture of the exudate.
- Provide local fluoride treatment.
- Assess the complete blood count with platelets if the patient has carried out a treatment cycle in the last 3 weeks.
- Administer antibiotic prophylaxis if neutrophilic granulocytes are less than $3,000/\text{mm}^3$.
- Postpone treatment if the platelets are less than $40,000/\text{mm}^3$.
- Ensure effective local hemostasis.
- Provide early treatment of mucositis and xerostomia.

Allergy to local anesthetics (cutaneous rash, angioedema, rhinorrhea, lacrimation, dyspnea, or dysphonia that develops a few minutes after the local anesthetic injection)

Possible problems:

- Localized allergic reaction
- Generalized allergic reaction
- Anaphylaxis

Prevention of complications:

- Identify with certainty the anesthetic that caused the reaction.
- Use a different anesthetic.

Note: There are two groups of anesthetics:

Group 1: esters of para-amino benzoic acid and of tetracaine (the majority of the allergic reactions take place with procaine; cross-reactions are possible among drugs of this class).

Group 2: amide derivatives (lidocaine, mepivacaine, prilocaine, bupivacaine; cross-reactions among these drugs are very uncommon); avoid amide-derivative solutions that contain methylparaben as a preservative.

Caution is necessary during the execution of the first injection when a different anesthetic is used: aspirate to make sure that the injection site is not a blood vessel; inject a small amount of anesthetic and extract the needle; wait at least 5 minutes; if no reaction occurs, complete the anesthesia, always ensuring that the needle is not in a blood vessel.

If the patient is not able to remember the drug implicated in the previous allergic reaction, two approaches can be adopted:

- Send the patient to an allergist to carry out skin tests (but false-positives are frequent) and a provocation test which, if negative, then allows the use of the tested anesthetic.
- Use an antihistamine (diphenhydramine, 1%) diluted and combined with 1:100,000 adrenaline without methylparaben as a preservative (50 mg total maximum dose for anesthesia).

The patient may report reactions to previous injection of anesthetics that might not have an allergic basis:

- Toxic reactions caused by injections in a vein (sense of drowsiness, drawled words, nausea, logorrhea, excitement, psychomotor agitation, convulsions, and depression)
- Reaction caused by a vasoconstrictor (palpitations, agitation, fear, sweat, and pallor)
- Psychomotor reactions: hyperventilation (sense of drowsiness caused by respiratory alkalosis); vasovagal reaction (nausea, pallor, bradycardia, sweat, and orthostatic hypotension); and sympathetic reaction (anxiety, tremor, palpitations, and hypertension)

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2

Oral Manifestations of Systemic Diseases: Problems Related to Prosthetic Treatment

Dentists are treating patients with systemic diseases more and more frequently. This situation is a result of the progressive aging of the population: It is estimated that by 2030, 20% of the human population will be 65 years or older. For this reason, it is important for the modern dentist to be able to recognize systemic diseases from their oral manifestations and to know the consequences of such diseases and their treatment for the dental treatment plan. In this respect, Morris's statement seems appropriate¹: "Dentists are now concerned not with the treatment of teeth in patients but the treatment of patients who have teeth."

A close relationship between the dentist and the internist is highly desirable. A careful orodental evaluation can contribute to the diagnosis of important systemic diseases, even those that are not yet manifested. A Japanese study² reported that 15% of patients with systemic diseases had been referred to a medical clinic by a dentist. The causes for which medical consultation was required were, in order of frequency, arterial hypertension (13.6%), hepatobiliary or pancreatic diseases (13.4%), heart diseases (9.5%), and diabetes (4.6%).

The aim of this chapter is to describe the oral manifestations of the most frequent systemic diseases and to evaluate the possible influence of such diseases on prosthetic treatment. The diseases discussed are cardiovascular diseases; cerebrovascular diseases; diabetes mellitus; osteomalacia and osteoporosis; chronic renal failure; respiratory diseases; gastroesophageal reflux, peptic ulcer, celiac disease, and Crohn disease; hepatic cirrhosis; neoplastic diseases; infection with human immunodeficiency virus 1 (HIV-1); autoimmune diseases; and nutritional disorders.

The definitions of the various diseases are drawn from *Harrison's Principles of Internal Medicine*.³ For clinical assessment and treatment of acute ailments, please refer to chapter 1.

Cardiovascular Diseases

The most relevant cardiac diseases are ischemic disease, arterial hypertension, disturbances of cardiac rhythm, heart valve diseases, primary and secondary myocardial dysfunction, and chronic heart failure. Oral manifestations of cardiovascular disorders are not specific, and their effects on dental treatment are generally the consequence of drug treatment rather than of a specific disease.

Definitions

Ischemic heart disease is the consequence of atherosclerotic degeneration of the coronary arteries that results in a discrepancy between oxygen needs and oxygen delivery to the myocardium. It is the main cause of sudden cardiac death. The various forms are stable angina (triggered by physical activity and improved by rest and by nitroglycerin), unstable angina (intermediate between angina and myocardial infarction), variant angina pectoris (precipitated by coronary spasm with or without coronary lesions), and myocardial infarction (acute occlusion of a branch of a coronary vessel with necrosis of the surrounding tissues served by the occluded vessel).

Arterial hypertension is defined as systolic pressure higher than 140 mm Hg and diastolic pressure greater than 90 mm Hg.

Disorders of cardiac rhythm are an abnormally low (bradyarrhythmia) or fast (tachyarrhythmia) arrhythmia resulting from either abnormal generation (automatism) or to abnormal conduction of the impulse.

Heart valve diseases. Cardiac valves may be affected by several diseases, such as rheumatic fever, congenital defects, ischemic heart disease, mitral valve prolapse, and systemic lupus erythematosus (SLE).

Heart failure results when the heart is unable to provide enough blood output to satisfy the metabolic needs of the tissues.

Oral manifestations

As previously mentioned, the oral manifestations of cardiovascular diseases are not specific and are often the consequence of pharmacologic treatment, rather than of the type of heart disease.⁴ The following are the most frequent cardiovascular drugs that cause oral abnormalities and the related manifestations:

- Angiotensin-converting enzyme (ACE) inhibitors: erythema multiforme, lichenoid dermatitis, xerostomia, loss of taste (captopril and enalapril), pharyngitis, burning sensation, ulcers, and angioedema
- β -Adrenergic blockers: xerostomia, lichenoid dermatitis, and paresthesia
- Calcium antagonists: gingival hyperplasia (found in 43.6% of patients treated with nifedipine), and sialorrhea (nicardipine)
- Diuretics: xerostomia and parotid gland hypertrophy (spironolactone)
- Nitrates: dental caries and alterations of the materials used as a prosthetic base (oral administration of long-acting glyceryl trinitrate)⁵

Problems related to prosthetic treatment

Most of the acute problems related to prosthetic treatment are the consequence of administration of anesthetics, vasoconstrictors, anticoagulants, and so on (see chapter 1).

Among the chronic complications, the most important is xerostomia from diuretic therapy, which is prescribed to most patients with cardiac diseases. Diuretics, besides producing a functional block of secretions, can cause, over time, real organic damage with progressive destruction of the acinar cells, which are very sensitive to physical and chemical attacks. The damage is aggravated by drug accumulation, in isotonic concentrations, in the acini of the accessory salivary glands.

In subjects with removable prostheses, diuretic-induced xerostomia can impair prosthesis retention.⁶ In addition, salivary deficit favors oral mucosa irritation (burning and itching) and the adhesion of food to the prosthetic material.

Cardiovascular diseases do not seem to be a risk factor for the success of osseointegration interventions.⁷

Cerebrovascular Diseases

The vascular diseases that affect the central nervous system are usually of two types: ischemic or hemorrhagic. Both types cause loss of cerebral function.

Oral manifestations

- Unilateral paralysis with dysarthria
- Reduced oral hygiene
- Drug-related abnormalities
- Manifestations secondary to nutritional disturbances

Problems related to prosthetic treatment

Prosthetic treatment, especially with removable prostheses, in patients who have suffered a stroke is complicated by several problems⁸:

- Advanced age: Most patients are elderly, and two thirds are edentulous. Loss of oral sensitivity leads to inability to control the position of the prosthesis. Other factors contributing to instability of removable prostheses are weight loss and drug-related xerostomia (from diuretics, ACE inhibitors, sedatives, and neuroleptics).
- Unilateral hypotonia favors prosthesis instability, amplified by tongue movement toward the hypotonic side.
- Loss of oral sensitivity favors the formation of decubitus ulcers.
- Weight loss may reduce bone density, but only temporarily; in fact, no prolonged effect has been documented.⁹

Diabetes Mellitus

Diabetes mellitus includes a heterogenic group of disorders all having in common alteration of glucose tolerance or impaired lipid and carbohydrate metabolism. Diabetes develops as a result of:

Insufficient insulin production (type 1 or insulin-dependent diabetes), usually subsequent to an autoimmune disease that destroys the β cells of the pancreas and more rarely due to a viral infection or to environmental factors. Type 1 diabetes usually develops in early childhood or adolescence and represents 5% to 10% of all cases of diabetes.

Abnormal insulin secretion and/or resistance (type 2 or non-insulin-dependent diabetes); in this type of diabetes, insulin deficiency is relative and not absolute. Type 2 diabetes represents 85% to 90% of cases, and the risk factors are age and obesity.

The prevalence of diabetes is difficult to assess, because the estimates are considerably influenced by the criteria used to define the disease: If glucose intolerance is used as the criterion, the prevalence is 6.6%; if fasting hyperglycemia is used, the

prevalence is only 1% to 2%. Regardless of the criterion used, the prevalence is constantly increasing.

Oral manifestations

Because the oral manifestations of diabetes are numerous and frequent, especially in patients with poorly controlled disease, the patient often ignores them.¹⁰ Diabetic periodontitis is actually considered to be the sixth most important complication of diabetes,¹¹ together with microangiopathy, neurologic disease, renal disease, vascular disease, and delayed wound healing.¹²

The severity of the manifestations is related to the duration of the disease¹³ and to the presence of renal and cardiovascular complications.¹⁴

The most common oral manifestations are periodontal disease, salivary gland dysfunction, fungal infections, and oral alterations.

Periodontal disease^{11,12}

Generally more severe in diabetic than in nondiabetic patients, periodontal disease is related to reduced function of polymorphonuclear leukocytes, disorders of collagen metabolism, and formation of advanced glycosylation end products that stimulate cytokine production (interleukin 1, insulin-like growth factor, and tumor necrosis factor α), all of which favor the destruction of the periodontal tissues,¹⁵ influencing collagen stability and vascular integrity. Increased loss of periodontal support is observed in patients with both type 1¹⁴ and type 2¹⁶ diabetes and is due to abnormal collagen synthesis, maturation, and homeostasis. Diabetes is not a risk factor for tooth loss (edentulism).¹⁷

The interaction between diabetes and periodontitis is reciprocal. In fact, chronic periodontitis may aggravate glucose intolerance. On the other hand, diabetes may worsen periodontitis, changing the microflora that colonizes periodontal pockets, increasing the prevalence of spirochetes and mobile bacteria, and reducing the prevalence of cocci.¹⁸ To prevent the changes in oral flora, the patient must maintain careful control of plaque, undergo frequent tartar removal, and abstain from smoking.¹⁰

Salivary gland dysfunction

Xerostomia, reduced parotid saliva flow,¹⁹ either spontaneous or stimulated, has been reported in 40% to 80% of diabetic patients.²⁰ It is related to dehydration and diabetic neuropathy of the autonomic nervous system.

Fungal infections

Oral candidiasis is frequent in patients with uncontrolled diabetes, especially those with oral prostheses.²¹ The manifestations are median rhomboid glossitis, prosthetic stomatitis, and angular cheilitis.

Oral burning, altered taste, and lichenoid lesions²¹

Oral burning sensations have been recognized in 37% of patients with type 2 diabetes and are thought to be caused by neuropathy, xerostomia, or candidiasis. Altered taste is often the consequence of oral antidiabetic therapy (biguanides) as are lichenoid lesions (chlorpropamide).

Problems related to prosthetic treatment

Diabetes is not a significant risk factor for prosthetic treatment, apart from causing a delay in wound healing.¹² Implant failure has been observed in only 6% to 7% of patients.^{22,23}

Bone Diseases

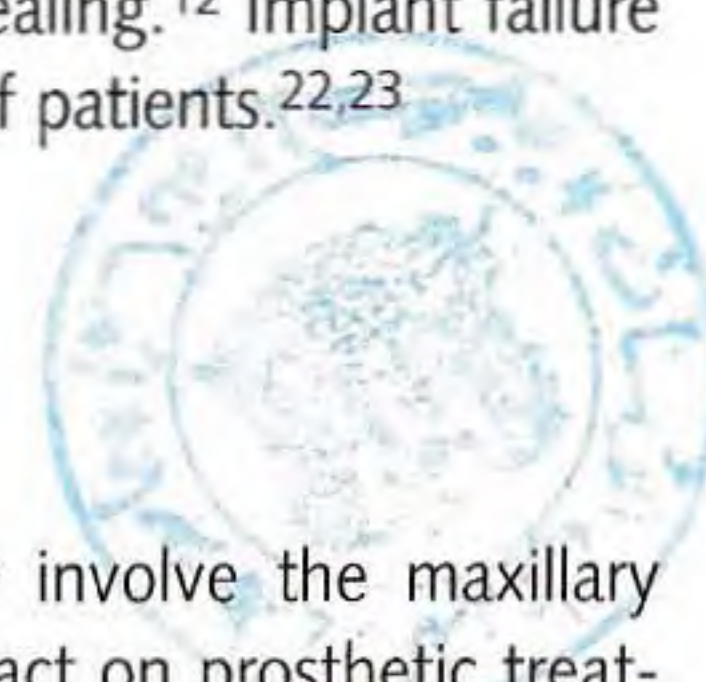
Diseases of the skeletal system rarely involve the maxillary bones and thus do not have great impact on prosthetic treatment. The most common bone diseases are osteomalacia and osteoporosis.

Osteomalacia

Bone mass is reduced in patients with diseases of the kidneys, liver, intestine, thyroid, and parathyroid. These pathologic conditions result in reduced calcium intake in the diet, reduced calcium absorption, and a deficit in vitamin D hydroxylation (essential for the calcium transport in the intestine). Vitamin D deficiency reduces bone mineralization, with excessive deposition of bone matrix and lowered content of calcium salts. If bone weakening occurs in childhood, during growth, it causes deformation of load-bearing bones (rachitism); if bone weakening occurs in adult subjects, it causes fragility and an increased tendency to fractures.

Oral manifestations

Tooth health is not greatly affected by vitamin D deficiency; the risk of caries is not increased. The abnormalities, encountered only in the most severe cases, are delayed eruption of teeth; formation of large pulpal cavities; and abnormal dentinal calcification.⁴



Problems related to prosthetic treatment

- Weakening of the endosteal portion of the cortical and intertrabecular bone
- Tendency to develop pulpitis and multiple, apparently spontaneous abscesses
- Load-induced deformation of the mandible and maxilla

Osteoporosis

Osteoporosis is characterized by a deficit of the bone matrix or mineralization (osteopenia). Several factors contribute to osteoporosis, such as aging, hormonal diseases, drugs (corticosteroids and heparin), inflammation, and immobility. These factors also affect oral health, leading to loss of teeth. Other important factors are alcoholism and cigarette smoking. The latter also causes alteration of local perfusion, inhibiting osteogenesis.

There are two types of osteoporosis: type I (postmenopausal), characterized by increased bone turnover, and type II (senile), with normal bone turnover.

Oral manifestations

There are no specific oral manifestation of osteoporosis and, even if probable, there is no confirmed association between osteoporosis and loss of bone tissue in the jaws.

Problems related to prosthetic treatment

From the numerous studies undertaken, osteoporosis does not appear to be a contraindication to prosthetic treatment.²⁴ According to Blomqvist et al,²⁵ reduction in bone density is a risk factor for failure of implants.

Chronic Renal Failure

Chronic renal failure is the consequence of progressive renal damage of various origins, leading to progressive loss of nephrons. Although chronic renal failure often begins subtly, it leads finally to uremia, a syndrome characterized by metabolic derangement (disturbed hydroelectrolytic balance and secondary hyperparathyroidism); cardiovascular abnormalities (systemic hypertension, uncontrolled cardiac congestion, cardiomyopathy, pericarditis, and development of atheromas); gastrointestinal diseases (anorexia, nausea, vomiting, hiccups, and peptic ulcer); neuromuscular diseases (asthenia, headache, visual and sensory disturbances, and tremor); dermatologic problems (prurigo, ecchymosis, and pigmentation); hematologic disorders (anemia, leukopenia, and hemorrhage); and decreased immune defenses.

Oral manifestations

Chronic renal failure with retention of nitrogenous products (uremia) presents with various manifestations, specific and non-specific in nature.

Nonspecific manifestations

Xerostomia, salivary gland hyperplasia, halitosis, metallic taste, pallor from anemia, bleeding and purpuric lesions on the mucosa, abnormalities of salivary electrolytes and proteins, and calculus deposition

In patients undergoing dialysis, protein deficiency (more frequent in patients undergoing peritoneal dialysis) and vitamin deficiency (vitamins B₆, C, and D and folic acid)

Uremic stomatitis

- Ulcerative stomatitis: superficial and painful ulcers of variable size, covered with pseudomembranes
- Nonulcerative stomatitis: edema, painful diffused erythema, thick grayish membrane

Manifestations in pediatric patients

- Early renal failure frequently causes oral manifestations consequent to abnormal metabolism of phosphorus and calcium²⁶:
- Delayed tooth eruption
- Malocclusions
- Diffuse enamel opacities (83%) and hypoplasia (22%)
- Gingival hyperplasia (not limited to that observed during immunosuppressive therapy with cyclosporin)

Problems related to prosthetic treatment

When treating uremic patients, the dentist needs to consider several problems.

Hemorrhagic diathesis

A tendency to bleeding can result from reduced platelet adhesion, deficit of platelet factor III and von Willebrand factor, or anticoagulant therapy (see chapter 1).

Renal osteodystrophy

This can be the result of secondary hyperparathyroidism and decreased hydroxylation of vitamin D₁ to 1,25-dihydroxycholecalciferol. The consequences of these abnormalities are loss of the lamina dura, osteoporosis, osteolytic areas, development of giant-cell lesions, delayed healing mechanisms, and alveolar sclerosis after tooth extraction.

Immunodepression

Depression of the immune system encourages local infections (oral candidiasis) and diffusion of dental infections to remote sites

Respiratory Diseases

Chronic obstructive pulmonary disease (COPD) is the most common respiratory disease, and the most significant one for oral health. The term *COPD* includes several diseases, such as chronic bronchitis, emphysema, bronchial asthma, and bronchiectasis.

Definitions

- *Chronic bronchitis* is the presence of cough with sputum for at least 3 months a year for 2 consecutive years.
- *Emphysema* is defined as lung overinflation with destruction of the spaces distal to the terminal bronchiole.
- *Asthma* is a chronic inflammatory airway disease with recurring episodes of wheezing, dyspnea, thoracic constriction, and coughing, especially in the night and early morning, associated with diffuse airway obstruction. Asthma is totally or partially reversible, spontaneously or with therapy.
- *Bronchiectasis* involves dilation and deformation of the bronchi, with hypersecretion and stanching of bronchial secretions and frequent overinfections. The disease can be a consequence of cystic fibrosis, a hereditary disease of the bronchial glands characterized by excessive mucus viscosity and increased concentration of sodium in the sweat.

The most significant of these diseases, in terms of dental care, is bronchial asthma.

Oral manifestations

The oral manifestations of asthma are generally attributable to antiasthmatic drugs, above all to inhaled corticosteroids and β_2 -agonists. In this regard, most of the drugs inhaled remain in the oropharyngeal cavity, while only 10% to 20% of the dose reaches the bronchial tree. Oral manifestations of bronchial asthma are:

- Increased accumulation of plaque and calculus,²⁷ severe gingivitis, and loss of the labial surface in anterior teeth and the occlusal surface in posterior teeth.²⁸
- Oropharyngeal candidiasis related to corticosteroid therapy, especially from inhaled drugs.

- An increased number of dental erosions²⁹ that can be attributed to prolonged therapy with β_2 -agonists,³⁰ which favors xerostomia and consequent proliferation of the cariogenic microorganism *Streptococcus mutans*.³¹
- An increased frequency of edentulism (odd ratio = 10.81), mainly due to the effect of drug therapy.¹⁷

Problems related to prosthetic treatment

Asthma patients exhibit increased apical external reabsorption of roots in the posterior teeth; this complication is supposed to be favored by the penetration of the inflammatory mediators implicated in asthma.³²

Gastrointestinal Diseases

There are many heterogenous diseases related to the mouth, esophagus, stomach, pancreas, and large and small intestines. Only the diseases of major interest to oral care will be discussed in this chapter.

Gastroesophageal reflux disease

The gastroenteric disease of major interest to the dentist is gastroesophageal reflux disease, which consists of the retrograde passage of gastric fluids from the stomach into the esophagus; the condition may or may not be associated with hiatal hernia and esophagitis.

Oral manifestations

Recent observations^{33,34} show that gastroesophageal reflux can provoke serious dental damage, even in asymptomatic subjects. The damage depends on exposure to acid gastric juices and affects mainly the areas of the mouth most exposed to the reflux (the lingual and occlusal surfaces of the maxillary premolars and anterior teeth).

The damage caused by the reflux consists of:

- Burning and irritation of the mouth and painful oral ulcers.
- Edematous gingival borders, reddened by the presence of plaque.
- Multiple, often pigmented, caries lesions on the interproximal surfaces of the mandibular teeth.

The most characteristic lesion of gastroesophageal reflux is dental erosion with loss of enamel and exposure of the underlying dentin in the mandibular anterior teeth. The erosion can reduce the vertical dimensions of the teeth, thus interfering with the masticatory process.

Problems related to prosthetic treatment

Decreased vertical dimension requires extensive prosthetic treatment

Gastroduodenal peptic ulcer

Peptic ulcer is a lesion of the mucosa generated by the effects of gastric acid and pepsin, often due to infection with *Helicobacter pylori*. Other causes of peptic ulcer are stress, ingestion of aspirin or nonsteroidal anti-inflammatory drugs, and gastrin-secreting tumors (Zollinger-Elison syndrome).

Dental problems related to peptic ulcer are the consequence of acid reflux (as in pyloric stenosis), the incidental malabsorption of iron and vitamins in case of gastrectomy (see the section on nutritional disorders), and the untoward effects on the oral cavity of drugs such as pirenzepine and/or sucralfate (xerostomia), ranitidine (erythema multiforme), and omeprazole (alteration of taste and erythema multiforme).

Diseases of the small intestine

This section describes only celiac and Crohn disease.

Celiac disease

Celiac disease originates from hypersensitivity to gliadin, a constituent protein of gluten, with consequent inflammation and destruction of the intestinal villi. Oral disturbances are related to malabsorption of certain nutritional elements and consist of anemic pallor, glossitis, burning mouth, angular cheilitis, recurring aphthous ulcers, and enamel hypoplasia.³⁵

Crohn disease

Together with ulcerative colitis, Crohn disease is one of the chronic inflammatory diseases of the intestine. Crohn disease is thought to represent an abnormal inflammatory response to normal intestinal flora, in which tumor necrosis factor α seems to play a major role. The pathologic picture consists of inflammatory infiltrate with noncaseous granulomas. Besides those related to malabsorption of nutritive elements, the oral manifestations of Crohn disease are the consequence of therapy with corticosteroids and immunosuppressive agents and consist mainly of ulcers and swelling.

Oral manifestations

The main manifestations of small-intestine diseases are related to malabsorption of nutrients, such as albumin, iron, folates, vitamin B₁₂, and liposoluble vitamins (see the section on nutritional disorders).

Hepatic Disease: Cirrhosis

Cirrhosis is the outcome of extensive damage of the hepatic parenchyma, which induces fibrosis, nodular regeneration, and vascular rearrangement. Various diseases lead to hepatic cirrhosis. Among the most common causes are toxic substances (alcohol and drugs), infections (hepatitis B and C viruses), and chronic vascular engorgement (congestive heart failure).

Oral manifestations

The oral manifestations of hepatic disease are various:

- Increased cariogenicity (especially in alcoholics), increased tooth loss, and stimulated salivary flow.³⁶
- Increased formation of periodontal pockets and loss of tooth attachment; gingival hyperplasia³⁷ is observed in patients receiving cyclosporine A after liver transplantation.
- Dental erosions as a result of frequent regurgitation of gastric fluids.
- Predisposition to oral cancer.
- Secondary manifestation hypoproteinemia (reduced intake and synthesis and increased catabolism of proteins), malabsorption of vitamins, anemia, and hemorrhagic diathesis.

Problems related to prosthetic treatment

- Disturbances of coagulation
- Difficult wound healing
- Disturbance of bone metabolism

Neoplastic Diseases

Because of the increased incidence of neoplastic diseases and of the increased survival of patients affected by such diseases because of improved antitumoral therapy, the dentist is more frequently faced with the treatment of patients affected by malignant tumors. Sometimes, dentists are the first persons who recognize the disease, either oral or extraoral tumors.

The most important oncologic diseases are acute and chronic leukemia, myeloma, lymphoma, and solid tumors at various localizations.

Oral manifestations

Oral manifestations result from oncologic diseases or their treatments. The most common will be discussed.^{4,38}

Leukemia

Leukemia is a neoplastic proliferation of white blood cells, consequent to specific genetic abnormalities. Acute leukemia is characterized by the release into peripheral blood of poorly differentiated myeloid progenitors (blasts); chronic leukemia is characterized by cells that maintain most of the characteristics of their corresponding normal cells. The oral manifestations consist of gingival bleeding, necrotic ulcers, leukemoid infiltrations, oral infections (candida, herpes virus, etc), tooth loss, and delayed healing of wounds.

Lymphoma

Lymphoma originates from the proliferation of any type of lymphocyte, both in the lymph nodes and external to the lymph nodes. Hodgkin lymphoma is derived from the monocytic-histiocytic series, while non-Hodgkin lymphoma derives mostly from B lymphocytes. Lymphomas represent 3.5% of all oral tumors, being found most frequently in the tonsils (32.7%) and the parotid glands (16.1%). Oral manifestations consist of frequent infections, anemia, and untoward effects of treatment with cytostatic drugs and corticosteroids.

Bone marrow transplantation complicated by graft-versus-host disease

In the acute form, the oral lesions are often painful, erythematous, ulcerative, and desquamative; in the chronic form, the lesions are lichenoid and are associated with erythema and ulcers, and sometimes with Sjögren syndrome.³⁹

Agranulocytosis

Severe ulcers may arise in the oral mucosa.

Thrombocytopenia

The oral manifestations are petechiae, ecchymosis, and gingival bleeding.

Solid tumors

These tumors can cause various oral manifestations:

- Metastases in the jaw or the soft tissues: tumors of the breast, lung, prostate, thyroid, kidney, stomach, and colon
- Effects of tumor metabolites: oral pigmentation (increased secretion of corticotropin-like compounds) and oral erosions (glucagonoma)
- Bleeding and anemia: liver and gastrointestinal tumors
- Mucocutaneous diseases: erythema multiforme, pemphigus, and herpetiform dermatitis

Chemotherapy

Chemotherapeutic agents are often the cause of oral complications, with a frequency of 90% in children and 50% in adults. The most common complications are:

- Infections (mycotic, viral, and bacterial). Among mycotic infections, candidiasis is one of the most frequent, particularly in the presence of severe leukopenia and antibiotic therapy. Among viruses, herpes virus infections are frequent and can cause chronic oral ulcers. Among bacteria, gram-negative infections (particularly *Pseudomonas*, *Klebsiella*, and Enterobacteriaceae) are frequent and show a rapid diffusion
- Ulcers and mucositis: The ulcers are often superficial, are mostly located on the labial mucosa, and heal 2 to 3 weeks after the end of cytostatic therapy.
- Xerostomia: The cytostatic drug that most frequently causes xerostomia is doxorubicin.
- Oral pain: The drugs derived from vegetable alkaloids (eg, vincristine) cause neurologic disturbances; the main oral manifestation is a pain similar to that of dental or periodontal origin that generally diminishes after the end of the chemotherapeutic cycle.

Local radiotherapy

Radiation therapy directed at the head and neck causes severe oral mucositis with ulcers, xerostomia, dysgeusia, ischemia, fibrosis of both soft and hard tissues, gingival recession, muscular fibrosis and trismus, and overinfections with *Candida*, viruses, and bacteria.

Problems related to prosthetic treatment

The treatment problems are multiple and generally caused by chemotherapy or radiotherapy. It is advisable to postpone rehabilitative interventions until after the oncologic therapy has been completed.

The effects of chemotherapy on osseointegration and dental implant survival are few. A recent observation in patients with tumors did not demonstrate any negative effect of postsurgical chemoadjuvant therapy with cisplatin and carboplatin and 5-fluorouracil.⁴⁰

HIV-1 Infection

Infection with HIV is a severe problem of public health around the world. The virus belongs to the retrovirus family, lentivirus subfamily. Sometimes, the infection begins with a mononucleosis-like syndrome, followed by an asymptomatic infection

phase that lasts from 1 to 20 years. In the late phase, fever and generalized lymphadenopathy occur.

Acquired immunodeficiency syndrome (AIDS) appears when the number of CD4 lymphocytes is less than 200/dL. The syndrome is characterized by high fever, diarrhea, loss of weight, neurologic disorders, secondary infective diseases, and tumors (Kaposi sarcoma, lymphoma, and cervical tumors).

The prevalent transmission routes are sexual contacts (especially homosexual but also heterosexual contacts) and contact with infected blood and blood derivatives (red blood cells, platelets, leukocytes, and plasma). HIV is not transmitted by hyperimmune serum, plasma-derived vaccines (eg, hepatitis B vaccine), or immunoglobulin Rh₀; this may be due to the fact that the preparation procedures of these products inactivate or destroy the virus. Although rare, work-related transmission is possible, particularly in health care-related occupations (eg, from injuries with infected needles). However, the risk of contracting HIV in this manner is much lower (0.3%) than that of contracting either hepatitis B virus (20% to 30%) or hepatitis C virus (10%).

Oral manifestations

Patients with HIV infection have various and severe oral infections⁴:

- Hyperplastic and/or pseudomembranous candidiasis.
- "Hairy" leukoplakia, nonremovable white lesions, on the edge of the tongue, apparently caused by the Epstein-Barr virus.
- Kaposi sarcoma, purplish spots that evolve into nodules; in the oral cavity, it usually develops on the palate.
- Herpetic stomatitis.
- Very painful aphthous ulcers on the posterior oropharyngeal wall that interfere with swallowing.
- Exfoliative angular cheilitis and frequent prosthetic stomatitis.
- Necrotizing ulcerative gingivitis.

Problems related to prosthetic treatment

The problems are usually the consequence of immunodeficiency, resulting in frequent infections, often from opportunistic agents; of hemorrhagic diathesis, caused by thrombocytopenia that develops in the advanced stage of the disease; and, rarely, of xerostomia due to parotitis (more common in children). Severe postextraction infections and osteomyelitis have been observed at the site of maxillary fracture. Careful and precise hygienic measures must be applied for every dental intervention.

Autoimmune Disorders

Autoimmune disorders are often diseases of unknown etiology that cause immunologically mediated degeneration of tissues. The most significant autoimmune disorders are Sjögren syndrome, rheumatoid arthritis, systemic lupus erythematosus, and systemic sclerosis. These diseases cause several oral manifestations.⁴¹

Sjögren syndrome

Sjögren syndrome is an autoimmune disease that affects the exocrine glands and is associated with rheumatoid arthritis or with other diseases such as primary biliary cirrhosis, systemic lupus erythematosus, or systemic progressive sclerosis. Disease manifestations are xerostomia, dry eyes (keratoconjunctivitis sicca), and multisystemic manifestations. This syndrome is one of the most common diseases of middle-aged women.

Oral manifestations

Reduced salivary secretions produce:

- Alterations of the oral flora,⁴² with prevalence of *S mutans*, *Lactobacillus* spp, and *Candida albicans* in the plaque, a proportional decrease in *Fusobacterium nucleatum* and *Prevotella* spp in the crevicular fluid, and disappearance of both *Porphyromonas gingivalis* and *Actinobacillus actinomycetemcomitans*.
- An increased number of caries lesions.⁴³
- A doubled risk of developing periodontitis.⁴⁴

Problems related to prosthetic treatment

Xerostomia alters the retention of removable prostheses. Abnormal osseointegration and a tendency to loss of bone mass⁴⁵ have also been observed.

Rheumatoid arthritis

Rheumatoid arthritis is a multisystemic immune-mediated disease, characterized by painful and deformed joints, that results from deposition of an immunoglobulin (rheumatoid factor) in the articulations that induces the formation of autoantibodies.

Oral manifestations

The main oral manifestations of rheumatoid arthritis are due to associated xerostomia (Sjögren syndrome).

Patients with long-standing rheumatoid arthritis, receiving drug therapy, show increased frequency of gingival bleeding, deeper periodontal pockets, more severe loss of epithelial attachment, and tooth loss.⁴⁶

Rheumatoid arthritis is frequently associated with periodontitis. Periodontitis is thought to be secondary to the deregulation of the inflammatory response typical of the disease.⁴⁷

Systemic lupus erythematosus

Systemic lupus erythematosus (SLE) is a disease of unknown etiology in which cells and tissues are damaged by pathogenic autoantibodies and immunocomplexes, with consequent multisystemic manifestations. The autoantibodies implicated in SLE are antinuclear, anti-DNA, anti-Sm, anti-RNP, anti-Ro (SS-A), anti-LA (SS-B), antihistone, antiphospholipids, antierythrocytes, antiplatelets, antilymphocytes, antineuronal, and antiribosome P.

Oral manifestations

The oral manifestations of SLE are rather rare and have atypical characteristics, difficult to differentiate from lichen planus and leukoplakia. In the discoid form of SLE, pathologic examination demonstrates hyperkeratosis, severe inflammatory infiltrations, and lamina propria edema.⁴⁸

Nutritional Disorders

The human body contains millions of molecules but needs only a few organic components: 9 essential amino acids, 1 fatty acid, and 13 vitamins, as well as water, minerals, and sufficient energy. The contrast between the simple nutritional requirements and the complex body components derives from the capacity to synthesize a vast number of organic compounds.

The most important nutritional deficiency and their relative oral manifestations will be discussed.

Deficiency of proteins and energy-giving substances

Protein deficiencies may originate from decreased dietetic supply or from coexistent acute or chronic diseases; they are often associated with other nutritional deficits and are present in about half of elderly hospitalized patients. Oral manifestations include atrophic glossitis with loss of papillae, reddening and atrophy of the oral mucosa, angular cheilitis, and burning mouth.

Iron deficiency

Lack of iron is often due to chronic blood loss and is associated with anemia. The most characteristic oral manifestation is Plummer-Vinson syndrome, which consists of atrophy of the oral mucosa, especially of the tongue papillae, with reddening and dysphagia.

Group B vitamin deficiency

The vitamins belonging to group B differ from each other with regard to alimentary origin, absorption route, and metabolic effects. The oral manifestations of the various types of deficiencies (which are often combined) are for the most part nonspecific and consist of mucositis, oral ulcers, glossitis, atrophy of tongue papillae (red and smooth tongue), dryness of the mucosa, and angular cheilitis. The most typical manifestations are:

Pellagrous glossitis, caused by niacin deficiency (hyperemic, scarlet red tongue, with prominent papillae and loss of patina; swollen tongue with teeth imprints) and associated with edema and reddening of the oral mucosa, burning mouth, gingivitis, angular cheilitis, and dysphagia.

Magenta tongue, arising from riboflavin deficiency (dark purple tongue with hyperemic papillae, giving a cobblestone appearance).

Vitamin C deficiency

This deficiency results in tumefaction and reddening of the marginal and interdental gingiva, petechiae, ecchymoses, gingival bleeding and swelling, ulcerations, and enamel hypoplasia in growing teeth.

Vitamin D deficiency

This deficiency is discussed in the section on osteomalacia.

Table 2-1 summarizes the principal oral manifestations of some common systemic diseases.

Table 2-1 Principal oral manifestations of systemic diseases

Manifestation disease or precipitating factor	
Xerostomia	
Drugs:	
– For cardiovascular diseases: diuretics, β -adrenergic blockers, angiotensin-converting enzyme (ACE) inhibitors	
– For respiratory diseases: β -adrenergic agonists	
– For peptic and gastroduodenal ulcers: pirenzepine, sucralfate	
Diabetes mellitus	
Chronic renal failure	
Cytostatic drugs	
Oral radiotherapy	
Sjögren syndrome	
Periodontal diseases, plaque, and tartar	
Diabetes mellitus	
Respiratory diseases	
Gastroesophageal reflux	
Hepatic disease	
Leukemia	
Thrombocytopenia	
Infection with human immunodeficiency virus (HIV-1)	
Sjögren syndrome	
Rheumatoid arthritis	
Cerebral vasculopathy (reduced oral hygiene)	
Oral mycosis	
Diabetes mellitus	
Corticosteroids	
Leukemia	
Lymphoma	
Chemotherapy	
HIV-1 infection	
Dental caries and erosions	
Nitro-derivative drugs	
β -adrenergic agonist drugs	
Gastroesophageal reflux	
Gastroduodenal peptic ulcer	
Liver diseases	
Sjögren syndrome	
Lichenoid reactions, burning mouth, and altered taste	
β -adrenergic blockers and ACE inhibitors	
Diabetes mellitus	
Gastroesophageal reflux	
Proton pump inhibitory drugs (omeprazole)	
Cytostatic drugs	
Oral radiotherapy	
Nutritional disorders (protein deficits)	
Celiac disease	
Oral ulcers, ecchymoses, and bleeding	
ACE inhibitors	
Leukemia	
Lymphoma	
Graft-versus-host disease	
Agranulocytosis	
Solid tumors	
Cytostatic drugs	
Oral radiotherapy	
HIV-1 infection	
Nutritional disorders (vitamin B and vitamin C deficiency)	
Chronic renal failure	
Gastroesophageal reflux	
Celiac disease	
Crohn disease	
Gingival hyperplasia	
Calcium-antagonist drugs (nifedipine)	
Cyclosporine	
Hydantoin	
Iron deficiency	
Chronic renal failure	
Sialorrhea	
Calcium antagonist drugs	
Plummer-Vinson syndrome	
Iron deficiency	
Delayed eruption	
Osteomalacia, vitamin D deficiency	
Chronic renal failure	
Paralysis with dysarthria	
Cerebral vasculopathy	

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3

Psychological Considerations

For prosthetic therapy to be successful, the dentist must establish effective communication with the patient. It is important, from the first contact, that a "treatment partnership" be established (using semistructured interviews) in such a way that the dentist understands the patient with regard to not only psychological but also social and cultural characteristics.

Psychological Aspects of Tooth Loss and Rehabilitation

A prosthetic intervention that modifies the oral cavity, whether fixed, removable, or an implant, involves the physical, psychological, and social aspects of the patient's life. In effect tooth loss, which society most commonly associates with aging, can have a dramatic impact on the perception of the patient's body and personal identity: The consequences for individual, interpersonal, and social aspects, as always, are correlated with expectations, which are influenced in turn by the cultural models projected by the mass media.

The partial or total absence of teeth not only makes mastication difficult but also affects, in a complex manner, the patient's quality of life. Physical injury or loss can be the basis of psychological difficulties and difficulties in the achievement of personal and social objectives. The loss of a tooth may be seen as the loss of a dear friend¹ and thus may be comparable to bereavement: The teeth, as organs of the body, are objects of direct emotional, esthetic, and functional investment.

Approximately 40% of the population have so-called fear of the dentist (dental phobia) and admit to avoiding the dentist except in situations of urgent need, because such an action is experienced as problematic, stressful, or anxiety and fear provoking. Many people avoid dental treatment because of psychological worries such as criticism of their oral hygiene, fear of losing control of themselves, and fear of pain, injections, and noise of the drill. There have been studies to determine if sensitivity to pain is related to fear of a dental visit.²

Some guidelines for interpersonal attitudes may be useful:

- The first meeting between the patient and the dentist should be held in a comfortable and private room.
- The treatment methods and the results should be described in a positive way, and techniques used to prevent pain should be explained.
- The dentist should adopt a calm, understanding attitude and empathize and share the patient's concerns.
- The dentist should understand the patient's feeling of fear and worry.

Frequently the patient is in an anxious state, has unexpressed anger, fear, or depression, and is reluctant to experience pain; these emotions can influence the patient's capacity to adapt to the loss of teeth and to prosthodontic interventions.³ In this respect, the patient may exhibit the following types of negative reaction⁴:

- Physical, but not psychological adaptation, resulting in negative alterations in the quality of the patient's life
- Neither physical nor psychological adaptation to the prosthesis, which may lead to an interaction with the dentist that involves long and complex nontherapeutic discussions either at a professional technical level or an emotional level
- An association of the loss of teeth with a personal failure and consequent refusal of treatment

These frustrating and unsatisfying situations generate stress in the patient and may lead the dentist to doubt his or her technical skills. The dentist then must proceed in the role of health educator, inspiring confidence and security in the patient, seeking to continue a helpful relationship with the patient, and alternating between appointments of dental examination and information. The majority of such patients need to arrive at a preliminary level of confidence and then test the relationship with the dentist.

The orofacial area of the body is very important, not only in the physical sense (as each tooth is considered an organ) but also in the construction of the person's identity. This area of the

body is strongly linked to the cortical area of the brain and is correlated with numerous psychosomatic disturbances, among which are temporomandibular problems, for people with or without teeth,⁵ that can negatively affect the person's well-being.

The dental prosthesis, although it generally brings an improvement, can in some cases become a factor that initiates or perpetuates different psychological disturbances. So a great deal depends on the manner in which the prosthesis is introduced to the patient's body image and lifestyle and the way in which the patient experiences the complex events of treatment: as a stress, often the last of a long series; as the only possible and long-awaited solution to various problems (not only dental); or as a sign of aging.

Prostheses, from the Greek *prósthesis* (meaning *addition*), are devices to replace a part of the human body with nonbiologic materials that reproduce the form and possibly the function. Thus, a prosthesis is something that the dentist proposes that the patient integrate into his or her mouth. The prosthesis must be appropriate, in both senses: appropriate in conforming to the requests and needs of the patient and appropriate in that it is made for the patient and will, it is hoped, become accepted as an integral part of the patient's own body. In the initial phase, a removable prosthesis is often considered as a therapeutic item and experienced as a foreign body.

It is important that the patient come to feel that the prosthesis is his or her own and that he or she be pleased with the effect of the prosthesis. For this reason, it is useful to request photographs from the patient of the time when the natural teeth were still present. The dentist then can prepare the prosthesis so that the visible teeth are similar in form, color, and alignment to the natural teeth. In this way, patients will more easily accept a new prosthesis, as they are able to recognize themselves (especially esthetically) in a way that they thought they had lost forever.

To have "new teeth" or "a new mouth" pushes patients to observe their mouths more critically and to pay more attention to the judgments and opinions of others. It is important that a relative or very close friend be present during the phases of esthetic treatment planning and try-in of the anterior teeth (for complete prostheses) or at the esthetic try-in sessions (for fixed prostheses). In this way, the patient has external esthetic feedback, which is often very important to the success of the prosthetic intervention.

New teeth are sometimes considered an isolated part of the body by patients. If this phase of "checking" and acceptance lasts a long time, not only the patient's overall identity but also the dentist-patient relationship can be compromised, and this may lead to conflict. Thus, the dentist must help the patient to accept and integrate the new element as a part of the body.

Many studies⁶ have underlined esthetics as the principal factor motivating acquisition of a dental prosthesis. The important criteria for the patient are adequate function along with health and esthetics. The objective of the intervention is to achieve good function of the prosthesis in both the physical and psychological aspects. For such patients, the outcome of the intervention must provide good masticatory function and a positive self-image and therefore a better quality of life.⁷

Prosthetic rehabilitation often combines technical-functional concerns with esthetic problems,⁸ as patients adapt themselves to the prosthesis as a substitution for their lost natural teeth. For these reasons, it is important to speak with patients during treatment,⁹ informing them of the different methods and their limitations, and to coordinate the intervention procedures, so as to reduce anxiety and prevent excessive expectations.

Effective communication between patients and health care providers is one of the basic parameters for successful treatment; this allows the patient to obtain information related to the risks, benefits, and costs of the treatment. A suitable process of encouragement will enable the patient to cope with the treatment and ensure good compliance and adaptation to therapy.

Communication

Dentists who provide prosthetic rehabilitation should dedicate part of their professional actions to communicating with their patients by talking, listening, and responding to questions. The different parts of communication, both verbal and nonverbal, help to establish an appropriate professional interpersonal rapport.

For example, the capacity to encourage dialog and maintain an attentive and tranquil facial expression is necessary in obtaining a satisfactory medical history so that a correct diagnosis can be reached. More than understanding the information given, it is important that the patient also develops confidence in the dentist. All this effort is useful for a good outcome of the therapeutic intervention. In fact, more and more patients want to be involved in decision making about their health (especially when related to the face, teeth, and oral cavity) and to be informed about and in agreement with the care and treatment proposed.

When speaking of the "role of the patient," the dentist should also consider that every person reacts differently, depending on feelings or reservations about oral and dental problems. A patient may consult a dental specialist for treatment, advice, or reassurance. A patient in pain often assumes a dependent role, especially in acute cases, and is dominated by feelings of uncertainty and fear.

Dentists can be confronted by various types of patients:

- Some patients assume the role of being sick. They are attention seekers; in general, they have already had many types of dental treatment over the years, and they feel unsatisfied and neglected.
- Some patients refuse this sick role because they do not want to recognize that they need treatment or a prosthesis.
- Some patients do not accept the possibility of having a handicap.
- Some patients are hypercritical.

The dentist, in all situations, must seek to establish a support system for the patient, positively integrating the psychological aspects. The dentist also must demonstrate an authentic interest, establish an appropriate interpersonal involvement, and at the same time intervene in a professional manner. This means maintaining a psychological distance that establishes an emotional buffer zone so that the dentist has the flexibility to modulate the type of communication and provide professional care.

An appropriate psychologically helpful relationship seeks to listen to and integrate the numerous requests of the patient while reconciling the patient's expectations with an appropriate and adequate treatment.

To achieve all this, it is important that the dentist understand the significant balance between being involved and keeping a correct distance and, in this way, be able to assume a "counter-view" regarding both the patient's psychological type and the clinical characteristics of the prosthetic treatment needed (Table 3-1). The dentist must therefore acquire a "cognitive-emotional behavioral" model as well as maintain the correct relationship and communication styles (both verbal and nonverbal) in keeping with the patient's clinical prosthetic needs.

Regarding the provision of information, within the ethical criteria of informed consent, it is possible to distinguish three levels of relationship between dentist and patients:

1. Action on the part of the dentist—passivity of the patient.

In this situation, the patient has a passive tendency and depends on the dentist to perform his or her work in an active and conscientious way. This is the type of relationship found in emergency interventions, analogous to the relationship of mother and infant.

2. Managing attitude of the dentist—participation of the patient. This is a more frequent model of relationship between dentist and patient, in which there is need for a certain level of cooperation. After having formulated a diagnosis, the dentist directs, counsels in an authoritarian manner, and expects the patient to cooperate. The analogous prototype of this kind of relationship is more evolved than that of the infant; it is similar to the stage of the child and early adolescent, in which it is expected that the patient is obedient to counsel and capable of responding to directions given in a rational, emotionally stable, and effective manner.

3. Mutual participation and collaboration between the dentist and the patient. This type of relationship is particularly useful in treatment of chronic diseases. The patient accepts the responsibility of the care and only infrequently consults the dentist, who helps the patient to care for himself or herself. The analogous prototype of the relationship is that which exists between two adults.

None of these models is necessarily the best or the worst; rather, they correspond coherently to specific situations and

Table 3-1 Effective responses from the dentist correlated with the personality traits of patients*

Patient's personality trait	Patient's responses to problems arising from prostheses and edentulism	Psychological relationships and interventions that may assist
Regressive dependence (reduced buffer zone)	Makes urgent requests	Provide support in coping with stress
Controlling	Exhibits self-discipline	Take scientific approach and share information
Dramatic	Acts unstable, irritable, and aggressive	Take a calming professional approach and control emotions
Fear of pain and suffering	Tends to refuse assistance	Acknowledge suffering and depression, without useless reassurance
Suspicion	Acts distrustful and complains	Accept the suspicion without discussion or contradiction; take preventive self-protective measures in case of eventual medical-legal-insurance proceedings
Hyperexigent	Exhibits pseudo-self-confidence	Adopt attitude of "expert"
Rigidly distant (enlarged buffer zone)	Seeks isolation	Modulate the distance; avoid complete withdrawal and seek communication channels that do not cause anxiety

*Adapted from Kahana and Bibring.¹⁰

Table 3-2 Basic models for dentist-patient relationship*

Clinical situation	Dentist	Patient	Analogous prototype
Emergency; trauma (eg, operation)	Action	Passivity	Mother-infant
Stressful event (eg, extraction)	Management	Cooperation	Parent-child
Participation in the dental prosthetic treatment	Request for collaboration	Compliance; treatment partnership	Adult-adult

*Adapted from Schneider.¹¹

patients in different clinical contexts. All the same, it is useful for the dentist to know how to use his or her professional communication skills to pass from one situation to another, according to needs (Table 3-2), as indicated in the following examples:

When the patient comes to the dentist with acute pain (emergency), the patient is suffering and therefore puts himself or herself completely in the hands of the dentist for treatment, trusting the professional to act decisively and freely to resolve the pain (mother-infant).

Subsequently, the patient will undergo appropriate treatments and possibly prosthetic rehabilitation (which may be stressful). The dentist acts in a managing mode but at the same time requests certain cooperation from the patient (parent-child).

When the treatments are completed, the next phase is follow-up, during which the patient follows the dentist's advice and takes responsibility in the maintenance of his or her own oral health (adult-adult).

It is important to provide the dentist (and the entire health care team) with the means to establish an adequate working relationship in the initial phases of the "treatment partnership." A guided interview used during the entire diagnostic-therapeutic course must be focused on some important areas of the patient's history (Box 3-1).

The growing access of patients to more complete information concerning oral and dental treatment will also increase their expectations about the variety of possible dental and pros-

thetic treatments. The clinician has, on the one hand, the obligation to respond satisfactorily to such requests and, on the other hand, the need to keep costs of treatment reasonable.

Occasionally, the dentist may propose priorities of choice in treatment planning, while at the same time welcoming and accommodating the patient's desires, in such a way as to start the process of greater decisional participation. The clinician can explain the range of possible options that would be technically efficacious, scientifically correct, and clinically valid. Thus "managed care" takes into account overall costs, quality of life, cultural orientations, and the presumed level of future health and satisfaction of the patient.

The use of some predictive indicators (such as objectives, resources available, and likely outcomes) may achieve a treatment plan that could be considered ideal. However, it is not always simple, when oral prosthetic treatment is started, to predict the signs that indicate the possible risks and the prognosis of treatment. In these areas, it is possible only to provide some clarifying suggestions. Box 3-2 describes some predictive indicators of possible difficulties in the therapeutic relationship during dental prosthetic treatment.

Beyond this predictive evaluation of patient attitude, the clinical discussion may include, in the diagnostic phase, an introduction of elements that may be helpful in the successive therapy: active listening, identification with the patient, trust and partnership in treatment, discussion of the role of stress, education about and the correction of distorted perceptions of body image, clarification of ideas, encouragement, and elaboration of similar clinical treatments.

Interviews and discussions are two useful techniques; the first obtains replies and the second encourages a more open dialog. It is an advantage if the patient has already worn a dental prosthesis, (1) because the patient is already accustomed to having a foreign body in the oral cavity, and (2) because he or she may have a critical judgment to make of the current prosthesis. Box 3-3 presents the type of interview that can be held with a patient who has a prosthesis.

A productive treatment partnership depends on the capacity of the entire health care team to enter into an empathetic unity in which the patient opens up and talks about the importance

Box 3-1 Guided interview

- Reconstruct the relevant critical moments in the patient's life, especially with regard to oral and dental treatment.
- Understand the specific significance and depth of the symptoms.
- Explore the motivation that has caused the patient to seek oral prosthetic treatment at this time of life.
- Evaluate the patient's expectations concerning the outcome.

Box 3-2 Predictive indicators and areas of communication**A Negative (risk) behavioral indicators****A1** Subtle behavioral aspects:

- Refusal of dental treatment (even when considered necessary)
- Reduced overall personal independence (physical, motor, family, economic, or social)
- Compromised in certain performance areas: cognitive, emotive, or interpersonal (eg, dementia-type disturbance)
- Extravagant or excessively eccentric requests (regarding specific proposals for dental treatment)

A2 Psychological aspects (often masked):

- Anxiety → pessimism
- Fear of pain → tries to avoid
- Fear that the treatment will be too costly
- Perfectionism regarding the probable results
- Excessive meticulousness in requests to the dentist
- General announcement of extreme fatigue in stressful situations
- Marked perplexity regarding the treatment plan and withdrawal from the therapeutic relationship
- Reduced enjoyment or approval of the dental team, expressed with suspicion and alarm
- Propensity to hypercriticism and feelings of blame regarding self and others
- General vindictive attitude toward medical professionals and specifically dentists
- Previous attempts at treatment of the same type being proposed (and postponed without a good reason)

A3 Social aspects:

- Insecurity toward interpersonal relationships (valid for treatment involving either fixed or removable prostheses):
- With the domestic partner (in the psychosexual dimension)
- In working relationships
- In other social contexts

B Positive behavioral indicators**B1** Explicit behavioral aspects:

- Cooperative and aware of the real therapeutic advantages
- Determined in decision making, even with respect to changes in the course of treatment
- Engaged in open and dynamic dialog about cost-benefits, frequency of appointments, and length of the full therapeutic treatment

B2 Psychological aspects (perhaps not evident):

- Empathetic reserve
- Practical realism toward the present deficit, the possibility of an efficacious cure, and the option of a removable prosthesis (positive coping)
- Acceptance and understanding of the compensation provided by the treatment (good compliance)
- Trust in the dentist regarding possible problems that may emerge

B3 Areas open to constructive dialog:

- Specific requests to the dentist regarding techniques, resources, length of treatment, and results
- Requests for clarification and clinical psychological or psychiatric support before or during treatment, and the possibility of communicating immediately with the dentist about any discomfort, desires, and dissatisfaction
- Specific requests from the dentist, in case of possible failure, to advise the patient to agree to eventual solutions

he or she assigns to the dental problem. A positive psychological approach can develop even in patients who are initially resistant at psychiatric evaluation,¹² because they often reveal personal information that provides an opening toward a relationship that is therapeutically useful. Professional contacts that offer encouragement and empathy enhance the level of cooperation from patients, promoting a treatment partnership.¹³

A duty of the team is also to evaluate, through interviews and discussions, both the structure of the personality and the

psychopathologic characteristics of the patient from the first encounter (see Table 3-1). The patient must therefore be interviewed to evaluate his or her:

- Ideas of treatment (see Box 3-1).
- Indicators of risk and positive attitude (see Box 3-2).
- Critical judgment of the old prosthesis (see Box 3-3).
- Psychological type with regard to being treated (see Table 3-1).

Box 3-3 Sample interview of a psychological nature for patients who already wear a dental prosthesis

Section A

- The thought of dental treatment has provoked or often will provoke:
- Anxiety, fear, specific phobias, depression, insomnia, a sense of having different physiognomic characteristics, or even other problems.
- The current dental prosthesis provokes:
- A sense of intolerable discomfort.
- Pain that is more or less intense.
- Chewing difficulties.
- Intolerance of anesthesia.
- Esthetic and phonetic worries.
- Refusal to wear the dental prosthesis.

Section B

- After this treatment, did you fear having functional or esthetic damage?
- Do you believe the treatment has been an advantage or a disadvantage? Of what type?
- Has the treatment been overall satisfactory in the time, physical discomfort, and cost incurred?
- Do you agree that the information provided was sufficient and timely?
- What were your real expectations and hoped-for results at the end of the treatment?
- Did you agree with the course of treatment?

Section C

- Whenever you need to communicate something important during or after the dental prosthetic treatment, do you think that the dentist is the person in whom to confide? Do you fear being unable to do this? Would you prefer to talk to another person in the treatment team?
- If an inherent psychological disturbance arises, whether directly related or unrelated to your dental treatment (depression, anxiety, insomnia, etc), would you consult the dentist for a psychopharmacologic cure or would you prefer to consult another specialist, in cooperation with the dental treatment team?

Section D

- Are there any other challenges or problems pertinent to this type of treatment that you have not communicated and would like to do so?
- Have you any other questions or information you would like to have answered (for example, about the atmosphere in which you were treated)?

In addition, the most common instruments¹⁴ for evaluating patients can be subdivided into two categories:

- 1. General measures that describe the cognitive-emotional behavior toward the process of adaptation
- 2. Specific measures that describe the patient perspective with regard to a particular pathologic syndrome

Conclusion

All of this information indicates how important it is to understand the patient through a complete diagnostic evaluation. The totality of this procedure allows for an analysis of the patient's expectations, the predictive aspects of the proposed intervention, and the outcome of the treatment itself.

Such a theoretical and practical approach, in addition to revealing psychological and specific existential aspects, can

become important in the therapy, representing a basis for a better relationship with the dentist and consequently a catalyst for the patient to take responsibility for his or her own oral health. This type of attitude likewise increases the psychological proficiency of the staff toward the prosthetic patient, who, during the various phases of treatment, may communicate that he or she has had psychological disturbances in the past.^{3,15} Such situations may already have been shown during basic screening, in the form of anxiety or aggression, symptoms of depression, manifestations of physical pain, or possibly other severe psychiatric disturbances. These problems contribute to and fuel a reverberating circuit between pain and state of mind that can result in refusal of treatment.

Although the tests and protocols are still incomplete, these practices are sufficiently tested so that the dentist can precisely outline the psychological profile of patients with inherent disturbances with regard to dental treatment and to note the psychological characteristics that play a predisposing, an aggravating, or a perpetuating role. Such situations require the further

development and validation of scientific and clinical protocols that are immediate, simple, and reproducible.

Nevertheless, specific psychological instruments that are useful in the research field may lose all value in the clinical setting because of the objective difficulties of systematic application and evaluation. It appears more appropriate, for clinical practice, to propose types of interviews that are sufficiently easy and flexible as well as effective for evaluating the principal psychological aspects and any potentially pathologic behavior (see Tables 3-1 and 3-2 and Boxes 3-1 to 3-3).

Successful communication in the dentist-patient relationship is indispensable, related to diagnostic and decision-making effectiveness and the therapeutic capacity of the psychological support system.¹¹ Establishment of such a treatment partnership is the basis of a good approach to therapy and a successful outcome of dental prosthetic treatment.

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4

Functional and Morphologic Considerations



Prosthetic rehabilitation of the oral cavity and jaws must be preceded by an evaluation of the morphologic and functional structures and of the oral ecosystem.

Functional Evaluation

Functional evaluation of the oral cavity is often neglected by dentists who prepare prostheses. In fact, a precise and satisfactory prosthetic rehabilitation can only be made for a patient who has no symptoms of dysfunction. The functional evaluation establishes the individual's level of dysfunction, alteration of movement of the mandible, or facial pain. The presence of musculoskeletal disease of the orofacial complex would indicate modifications or at least precautionary measures during the course of the prosthetic therapy. Such evaluations during diagnosis will avoid development of chronic pain; deterioration of the patient-dentist relationship; and problems of a medicolegal nature.

Pain in the masticatory muscles or the temporomandibular joint (TMJ), alteration of the mandibular movements, and joint sounds are rather common events. A series of studies in the 1970s¹ documented the high prevalence and incidence of these signs and symptoms, collectively known as *temporomandibular disorders (TMDs)*, *craniomandibular dysfunction*, or *myoarthropathy*. However, even if TMDs are the most common cause of signs and symptoms such as limited jaw movement or facial pain, many other disease entities, a few life threatening for the patient, can produce similar signs and symptoms. The first problem is therefore to recognize the cases in which the signs and symptoms are the result of a disease linked to the TMJ; therefore, it is important to consider other diagnoses of a more general nature before a definitive diagnosis of TMJ problems is made. The results of research about these problems are unclear, as comparison of clinical studies and interpretation of the outcomes of therapeutic procedures have been frustrated by a lack of standard diagnostic criteria for the various TMJ diseases.

Classification of TMDs

Many classifications have been proposed, using orthopedic, biopsychosocial, rheumatologic, and other bases proposed by committees of experts. These are often criticized as unsatisfactory because of the descriptive approach, lack of validation, lack of specificity, and the possibility of recording multiple diagnoses. To overcome these problems, a set of criteria for TMDs has been proposed,² based on operative definitions of the terms used in *Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD)*. As in other classifications of painful syndromes, two axes are used: observation and measurement of physical criteria (Axis I) coordinated with an evaluation of the implicated psychoaffective and social aspects (Axis II).

Axis I

The physical diagnosis of TMD includes three groups of observations: muscle disorders, disc displacements, and the group arthralgia, arthritis, and arthrosis (Box 4-1). Other, rather rare, musculoskeletal diseases are deliberately omitted, as are other diseases that can involve problems of differential diagnosis.

Box 4-1 RDC/TMD Axis I: Clinical conditions

Group I: Muscular pathology

- Myofascial pain
- Myofascial pain with limited jaw opening

Group II: Disc displacement

- Disc displacement with reduction
- Disc displacement without reduction but with limited opening
- Disc displacement without reduction or limited opening

Group III: Arthralgia, arthritis, and arthrosis

- Arthralgia
- Osteoarthritis of the TMJ
- Osteoarthrosis of the TMJ

Myofascial pain

Muscular pain is the most common cause of pain, both in patients with chronic pain and in the asymptomatic population. The use of the terms *myofascial pain syndrome* and *trigger points* is controversial and for this reason is best avoided. Although the general characteristics of pain related to muscles of the head and neck are commonly noted, described patterns of pain³⁻⁵ have only been partially confirmed in experiments. It is important to remember that suspected masticatory muscle pain is difficult to distinguish from fibromyalgia, defined as diffuse pain that increases on palpation of between 11 and 18 specific points of the body, except those of the masticatory system.⁶ Between 18% and 35.5% of patients with fibromyalgia also have referred facial pain^{7,8}; from the prognostic point of view, patients affected by generalized fibromyalgia have a greater tendency to chronic pain and onset of repeated episodes of orofacial pain. Missed diagnosis of this disease may prolong the length of oral rehabilitation therapy and may compromise the success of the treatment.

In the past many etiologic hypotheses have been proposed but not confirmed:

These include hypotheses based on correlations, not implicating a cause-effect relationship; in particular only minor (if any) etiologic roles of occlusal and articulatory parameters have been demonstrated in the development of muscle pain or other signs or symptoms of TMD.⁹

The existence of a vicious circle—"pain that causes muscular hyperactivity that in turn generates more pain"¹⁰—has been disproved: Critical evaluation of the literature and experimental data indicates that parafunctional habits are very common and usually are not present in TMDs; patients with painful bruxism have fewer episodes of bruxism than those with nonpainful bruxism; and heavy exercise results in pain that is of short duration but does not lead to a vicious circle, because it is only a "training effect."^{11,12} In addition, patients affected by TMDs do not show an increase in the postural electromyographic activity of the masticatory muscles or show signs of hyperexcitability.

Muscle pain results in a decrease in maximum voluntary muscle strength, a lessening of work capacity, and a decrease in rapidity and range of movements. It seems that the model of adaptation to pain by reduced muscle performance rather than that of pain-hyperactivity-pain is more likely. A consequence of this way of thinking has been to refocus attention to systemic rather than local factors. The theory is that pain on palpation could be linked with sensitive central hyperexcitability and a change in the centrally mediated pain as a result of peripheral noxae, causing an overall increase in sensitivity toward stimuli that would otherwise not be painful.¹³

Box 4-2 Diagnosis of muscular disease

- *1a: Myofascial pain.* History of pain (in the jaw, temple, face, preauricular area, or auricular area) either when resting or when functioning/chewing and presence of painful areas on palpation of muscles (between 3 and 20 points of pain: posterior, middle, anterior temporal area; origin, body, or insertion of the masseter muscle; posterior mandibular area; submandibular area; lateral pterygoid area; temporal tendon; at least one of these areas must be on the same side of the patient as the pain in question).
- *1b: Myofascial pain with limited jaw opening.* Same as for diagnosis 1a and a spontaneous jaw opening of 40 mm or less without pain as well as passive jaw opening as least 5 mm wider than the previous limit.

Diagnosis of muscle disorders

The diagnosis of masticatory myalgia is usually made by palpation of the muscle involved (Box 4-2), even though there is a lack of scientifically demonstrated diagnostic indicators or useful markers (immunologic, metabolic, electromyographic registration, or movement). Manual palpation¹⁴ or algometry can identify the muscle groups with or without pain. However, algometry identifies a larger number of painful points and areas than does manual palpation, and the number of painful points is a fundamental criteria for diagnosis.^{2,6}

Disc displacement

Until the 1970s,¹⁵ particular attention to the position of the disc and treatments that aimed at reestablishing a "normal" position between disc and condyle were common. There is a clinical distinction between a displacement (usually anteromedial) of the disc with reduction (click) and one without reduction (closed lock). The latter condition can also be accompanied by a limitation in opening.² In the past, the motivation for early diagnosis and treatment of disc displacement was the assumption that the anterior position of the disc was directly correlated with pain, limited movement (in the case of a disc displacement without reduction), and the development of arthritis. Recently the role of disc position has been reconsidered, both in relation to arthritis of the TMJ and in the interpretation of, as well as the indications for, diagnostic techniques and complex therapy.

There is agreement about the high prevalence of disc displacements in the population (30% to 50%). Longitudinal data obtained from adolescents¹⁶ and other age groups¹⁷ indicate that a clicking TMJ rarely becomes a disc displacement without reduction and that these symptoms should not be considered a

predictive indication of such an event. Further, it has been reported that TMJ clicks recur in a cyclic manner and are not predictable over time and that clicking, if it is the only symptom, does not require treatment.¹⁸

In certain patients with disc displacements, mandibular movements increase pain; this suggests that traction or pressure on the retrodiscal ligament tissues is the principal cause. The majority of patients, however, do not report pain in association with clicking, and, even when the displacement is nonreducible, pain is often absent. Evidently the aforementioned cause cannot be considered a general mechanism. One hypothesis to explain these facts could be the speed at which the displacement occurs: If displacement is rather slow, the tissues will adapt to the biomechanical changes; if rapid, eg, due to trauma, there will be pain. Concerning the pain, longitudinal studies have demonstrated that noninvasive therapy brings long-term results in most patients, independently of the position of the disc displacements.^{19,20}

The interaction between articular displacement and the development of degenerative arthritis is still not clear. Whether in primary or secondary arthrosis, a mechanical, biochemical, inflammatory, or other insult can alter the equilibrium between form and function, maintained by continual remodeling, and lead to destruction of the articular cartilage. Disc displacements can be considered either as a causal factor of arthritis, because of possible overloading of the articular cartilage, or as a sign of arthritis, in which the modification of the sliding action of the cartilage and the deterioration of the synovial liquid lead to friction, wear, and probably disc displacement.²¹

Diagnosis of disc displacements

Disc displacements, both with and without reduction, are diagnosed through history and clinical investigation (Box 4-3).

Articular sounds can be studied by manual palpation or by use of a stethoscope, with reasonable intraexaminer and interexaminer reproducibility. Electronic systems have not been found to be clinically necessary. For disc displacement without reduction, the diagnosis is sometimes complicated and more uncertain if the patient has slack ligaments, limited opening of the mouth, or asymmetric lateral movements of the jaw. Magnetic nuclear resonance is the system of choice to study the disc position in these patients, but the use of this imaging technology must be limited to cases where there is doubt or there is need to modify the therapeutic approach.

Degenerative and inflammatory diseases of the joints

Animal models and molecular biologic developments are clarifying the complex metabolism of joint cartilage. Factors such as sex hormones, age, the effects of stress and pain, trauma, systemic diseases, diet, and smoking may change the adaptive

Box 4-3 Diagnosis of disc displacements

- **2a: Disc displacement with reduction.** Reproducible reciprocal clicking in a least two of three consecutive tries, or clicking on opening or closing laterally (or in protrusion), again in two of three tries. If pain is present, check for diagnosis 3a or 3b (see Box 4-4).
- **2b: Disc displacement without reduction and with limited opening.** Clinical history of significant limited opening; objective signs: spontaneous opening of less than 35 mm and passive opening of no more than 4 mm greater than spontaneous opening, with contralateral movement of less than 7 mm and/or ipsilateral deviation at opening and absence of sounds or the presence of sounds not similar to those described in diagnosis 2a.
- **2c: Disc displacement without reduction and without limited opening.** Clinical history without significant limitation of opening; objective signs: spontaneous opening of more than 35 mm and passive opening of 5 mm greater than the spontaneous opening, with contralateral movement greater than 7 mm and the presence of sounds not similar to those described in diagnosis 2a.

capacity of the TMJ. It is also useful to remember that the peripheral nervous system, in addition to being the basis of nociception, also plays an active part in the inflammatory processes, releasing substances whose presence has been correlated with the level of damage and pain in the joints. Box 4-4 presents criteria for diagnosis of the degenerative and inflammatory joint diseases.

Box 4-4 Diagnosis of arthralgia, arthritis, and arthrosis

- **3a: Arthralgia.** History of pain in the joint and/or pain during the maximum spontaneous opening or lateral movements and pain at palpation at the posterior or lateral poles of the TMJ. Absence of crepitus.
- **3b: Arthritis.** Same as for diagnosis 3a plus crepitus noises and/or radiographic evidence of at least one of the following signs: cortical erosion, sclerosis, flattening, or osteophytes.
- **3c: Arthrosis.** Absence of signs listed in 3a plus the presence of crepitus noises and/or radiographic evidence of one or more of the signs listed in diagnosis 3b.

Axis II

Every physical diagnosis of Axis I must be integrated with a diagnosis of Axis II; that is, an assessment of the intensity of pain, the disability and discomfort created by the pain, and the psychological state of the patient must be made. A discussion with the patient about the history is fundamental to this process, because it is the key to identifying patients who are biopsychosocially compromised. In general, serious psychological problems and chronic pain must be dealt with through interdisciplinary therapeutic approaches. These are cases for which there is a high probability of failure. A standard checklist of seven points can be used as part of the TMD assessment to estimate the pain level of a mandibular disability.² Of course, other systems can be used; however, the importance of an effective and systematic evaluation for all patients cannot be overestimated.

TMDs and occlusion

There is still considerable disagreement concerning the role of occlusion. Some clinicians think that occlusion can be an important etiologic factor and for this reason propose occlusal therapy. Others, on the basis of scientific evidence, believe that the effect of the occlusion has only a marginal effect. Certain conclusions of importance for clinicians can be gathered from the scientific literature:

- Many epidemiologic studies^{22–24} have indicated that there is no proven relationship between occlusal factors and TMD.
- Orthodontic anomalies such as open bite, deep bite, and prognathism have not been correlated with TMD. The association between TMD and malocclusion is very weak or nonexistent.²⁵
- The intensity of dysfunctional symptoms is not correlated with the number of opposing teeth.²⁶
- In people not being treated for TMDs, no correlation between function and loss of molars has been found.^{27,28}
- No increase in TMD with age or loss of molars has been found.²⁹

Occlusion cannot be considered the only etiologic factor or the most important factor in TMDs. However, the occlusion has a central role in daily oral care and particularly prosthetic care.³⁰ This is particularly true for patients who suffer from TMJ problems and those who need prosthetic rehabilitation that involves the occlusion. Thus, while the occlusion is important in oral care, from the therapeutic view it must be seen as a means to improve the efficiency of mastication and other oral functions.

When considering the importance or need of prosthetic treatment in a patient with TMD, the clinician must clarify whether there are muscular and/or articular problems using the

criteria listed (Axis I) and establish the level of psychosocial discomfort or embarrassment caused to the patient (Axis II).

Thus a careful history and clinical investigation of the oral cavity must be performed using a practical approach, prior to a careful analysis of the information collected. The following elements are very important.

Personal data and chief complaints

During the initial meeting, it is very important to elucidate the patient's reason for seeking treatment³¹ and to allow the patient to explain his or her motives and hopes regarding the results of treatment.

Systemic medical history

See chapter 1 for a discussion of the data collection on the general medical history of the patient and chapter 2 for a description of oral manifestations of systemic diseases that might have repercussions for oral treatment. A systematic general history is fundamental to the differential diagnosis, because a patient who is affected by TMD can present with other pathologies (headache, neck pain, fibromyalgia, etc). However, an appraisal of the patient's general health can often indirectly reveal the approximate involvement of psychosocial and emotional factors.

Specific case history

A discussion of the case history allows the clinician to establish a relationship of trust with the patient. Only when the patient is certain of receiving the necessary attention from the dentist will he or she open up psychologically. The interview must happen in an atmosphere in which the patient is comfortable. Adequate time must be given the process, and external interruptions should be prevented. The dentist should not come to the patient with an air of superiority or inferiority, but as an equal. The dentist must avoid monopolizing the conversation and should listen to the patient's story without interruption. During the interview, careful observation of the patient can elicit the patient's general state of mind (eg, emotional, anxious) from the physical behavior (eg, oral parafunction, excessive movement of the hands and the legs).

A history and discussion also allows the clinician to (1) collect useful information to differentiate the causes of orofacial pain that are not related to the TMJ; (2) identify possible psychological and psychiatric, often depressive, problems; (3) identify factors correlated with the dysfunction that may improve or aggravate the situation; and (4) establish whether the oral prosthetic rehabilitation can be started immediately, or if specific therapy for a TMD is needed.

A detailed history can assist in determining the need for the intervention of other specialists to complete the diagnosis and therapeutic strategy (Fig 4-1). In the craniomandibular area, the

European Academy of Craniomandibular Disorders



Examination Protocol

Patient's name _____

Physician _____

Address _____

Address _____

Occupation _____

Examination date _____

Chief complaint: _____

History

Date _____

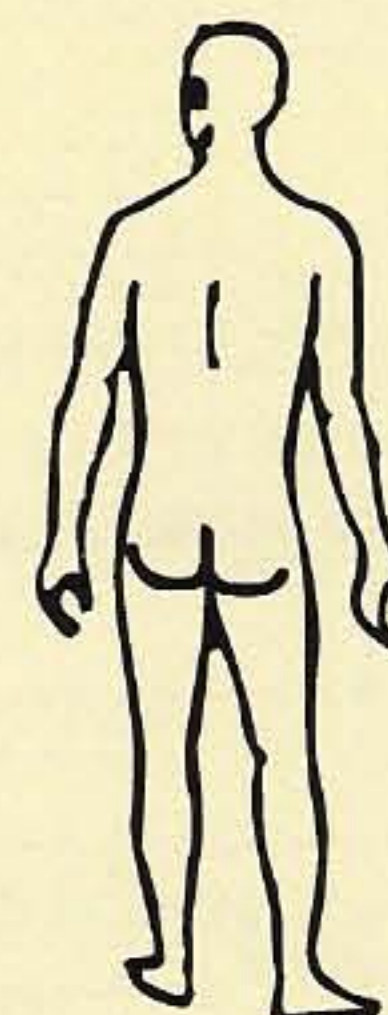
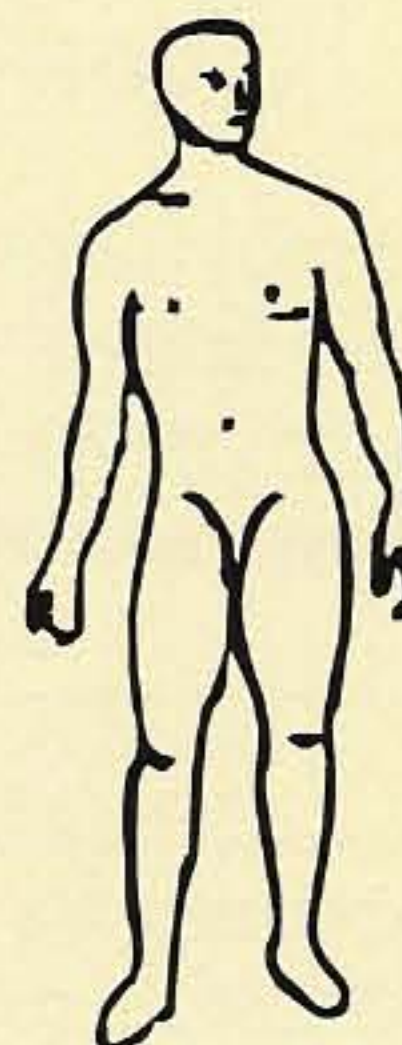
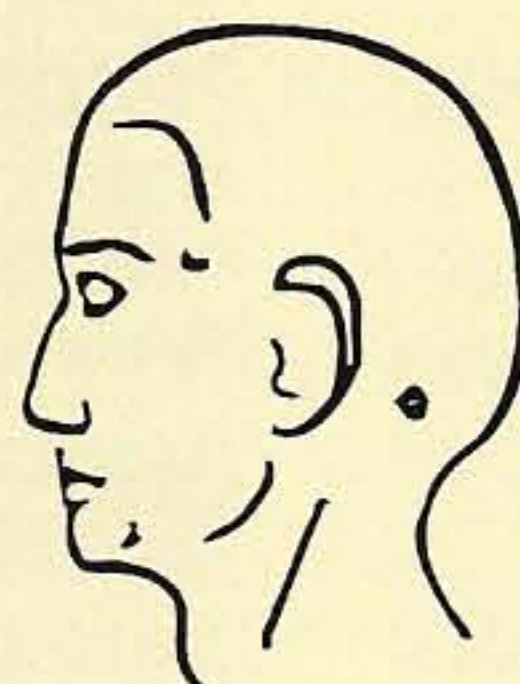
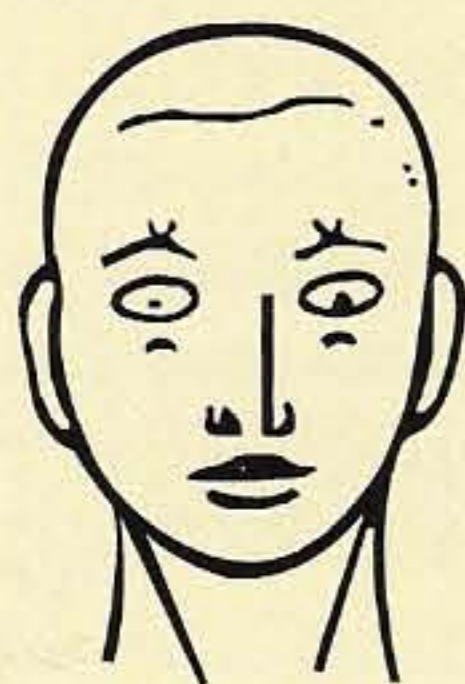
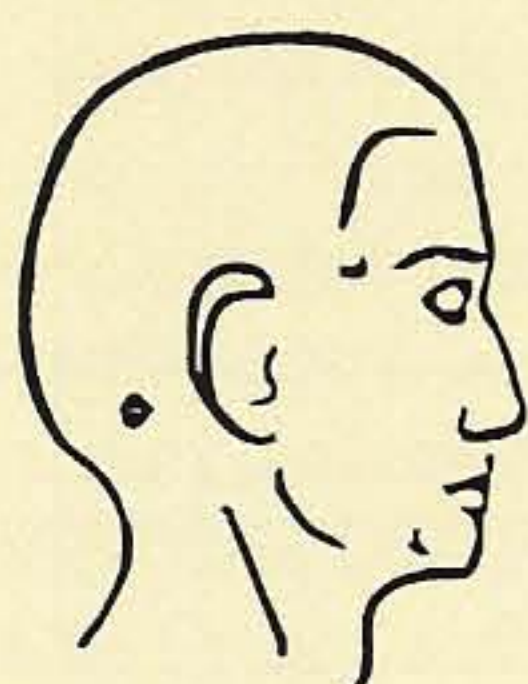
		Yes			
Pain	Face	☐	Do you have or did you have a history of?		Yes
	Head	☐		Infection (hepatitis)	☐
	Ear	☐		Heart and cardiovascular diseases	☐
	Eye	☐		Blood diseases	☐
	Neck	☐		Respiratory tract diseases	☐
	Frequent headaches	☐		Digestive tract diseases	☐
TMJ sounds	Clicking	☐		Urinary and genital diseases	☐
	Other noises	☐		Neurologic diseases	☐
Disturbances of mandibular function	Difficulties in opening, closing, chewing, muscular tiredness, stiffness of the jaw	☐		Metabolism	☐
		☐		Allergies	☐
		☐		Rheumatoid diseases	☐
Oral habits	Nail or lip biting, smoking, etc.	☐		Psychological problems	☐
Previous extensive dental treatments	Prosthodontics	☐		Hormonal problems	☐
	Orthodontics	☐	Pregnancy	☐	
	Surgery	☐	Trauma	☐	
	Equilibration	☐	Drugs	☐	
Are you comfortable with the way your teeth fit together?		☐ Yes ☐ No	General anesthesia or surgery	☐	

Fig 4-1 Medical history questionnaire for patients with TMDs (*part 1*). (Adapted with permission from the examination protocol of the European Academy of Craniomandibular Disorders.)

History

Pain

Date _____



Area # 1

Severity of pain

0

10

Parafunctions (oral, occlusal,
other parts of the body)

Trauma

Environmental factors

Family _____

Profession _____

Social position _____

Additional questions

Do you have sleep pattern disturbances? _____

Does your problem interfere with your daily life or affect your well-being? _____

What do you think is the cause of your problem? _____

Have you had treatment for this problem? _____

What do you expect from treatment? _____

Fig 4-1 Medical history questionnaire for patients with TMDs (*part 2*). (Adapted with permission from the examination protocol of the European Academy of Craniomandibular Disorders.)

Clinical examination

Mandibular range of motion

LR Act. ☐ Pass. ☐ mm Pain ☐ P Act. ☐ Pass. ☐ mm Pain ☐ LL Act. ☐ Pass. ☐ mm Pain ☐		<table border="1" style="margin: auto; border-collapse: collapse;"> <tr> <td style="width: 33%; text-align: center;">R</td> <td style="width: 33%; text-align: center;">C</td> <td style="width: 33%; text-align: center;">L</td> </tr> <tr> <td style="height: 40px;"></td> <td style="height: 40px;"></td> <td style="height: 40px;"></td> </tr> <tr> <td style="height: 40px;"></td> <td style="height: 40px;"></td> <td style="height: 40px;"></td> </tr> <tr> <td style="height: 40px;"></td> <td style="height: 40px;"></td> <td style="height: 40px;"></td> </tr> </table> Auscultation TMJ O Act. ☐ Pass. ☐ mm Pain ☐ Auscultation TMJ	R	C	L									
R	C	L												

R	O	C	P	Deviation on movement	P	C	O	L

Endfeel

	O	LR	LL
Elastic			
Stiff			

Auscultation of
the TMJ

R	O	C	LR	LL	P		P	LL	LR	C	O	L
							Clicking					
							Crepitation					

Joint play

Traction	Painful	P		L	
Translation	Painful				
	Smooth				
	Rough				

Palpation of the
TMJ

Laterally		P		L	
Posteriorly					
During movements	Laterally				
	Posteriorly				

Palpation of the
muscles

	P	<	=	>	L
Temporal					
Masseter					
Median pterygoid					
Sternocleidomastoid					

	P	<	=	>	L
Neck					
Shoulder					
Suprahyoid					
Tongue					

Fig 4-2 Clinical examination protocol for patients with TMDs. (L) Left; (R) right; (LR) lateral right; (LL) lateral left; (P) protrusion; (Act.) active; (Pass.) passive; (C) during closure; (O) during opening; (ICP) intercuspal position; (RCP) retruded contact position. (Adapted with permission from the examination protocol of the European Academy of Craniomandibular Disorders.)

Clinical examination

Manipulation of the mandible

Easy ○ Difficult ○ Impossible ○
 Slide RCP-ICP Sagittal mm Vertical mm
 Lateral R mm Lateral L mm
 Overbite mm Overjet mm

ICP

18	17	16	15	14	13	12	11
48	47	46	45	44	43	42	41

21	22	23	24	25	26	27	28
31	32	33	34	35	36	37	38

RCP

18	17	16	15	14	13	12	11
48	47	46	45	44	43	42	41

21	22	23	24	25	26	27	28
31	32	33	34	35	36	37	38

LR Laterotrusive side

18	17	16	15	14	13	12	11
48	47	46	45	44	43	42	41

Mediotrusive side

21	22	23	24	25	26	27	28
31	32	33	34	35	36	37	38

Mediotrusive contact / interference

LL Mediotrusive side

18	17	16	15	14	13	12	11
48	47	46	45	44	43	42	41

Laterotrusive side

21	22	23	24	25	26	27	28
31	32	33	34	35	36	37	38

Mediotrusive contact / interference

Protrusion

18	17	16	15	14	13	12	11
48	47	46	45	44	43	42	41

Mediotrusive side

21	22	23	24	25	26	27	28
31	32	33	34	35	36	37	38

Protrusive contact / interference

Protrusive contact / interference

Shiny facets and/or fractures / tooth mobility

Mediotrusive side

18	17	16	15	14	13	12	11
48	47	46	45	44	43	42	41

21	22	23	24	25	26	27	28
31	32	33	34	35	36	37	38

Additional findings (endodontics, orthodontics, and periodontics)

Provisional diagnosis

Fig 4-2 (cont'd)



Fig 4-3 The incisal margin of the maxillary incisors and the midline are marked with a felt pen on the mandibular incisors.

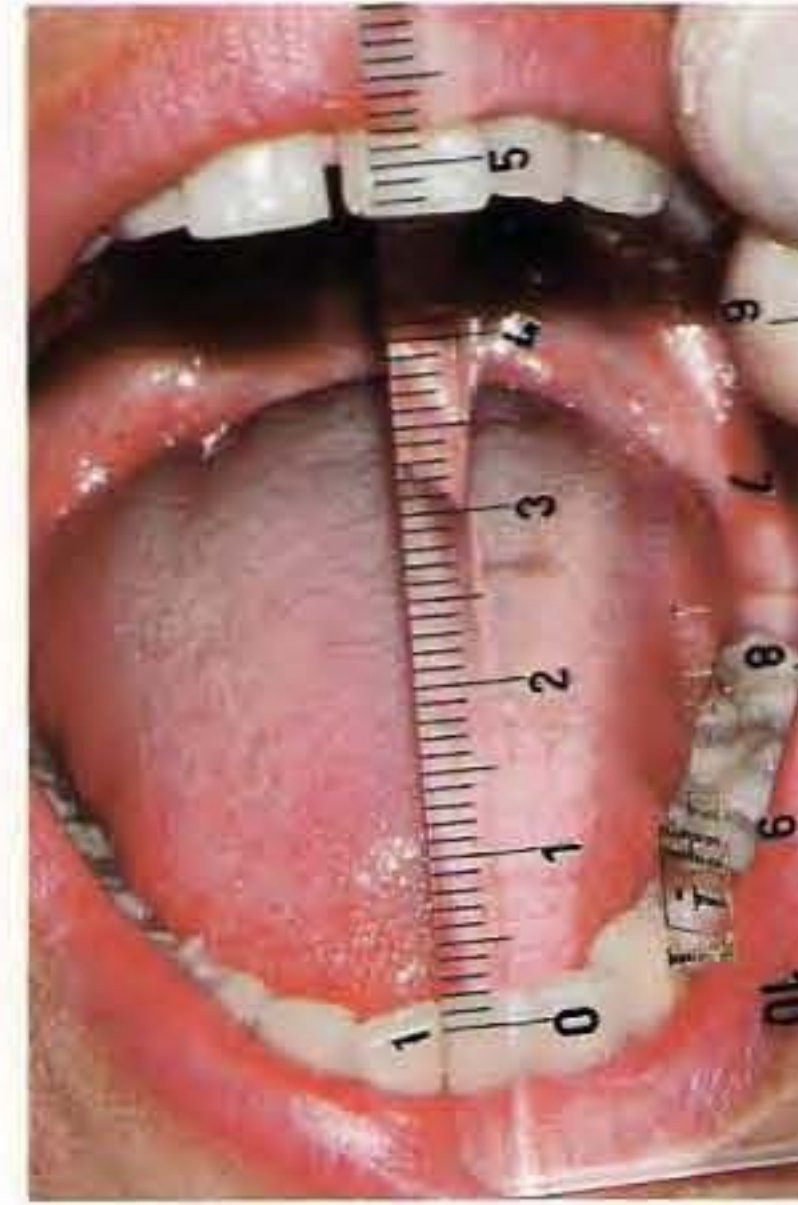


Fig 4-4 The physiologic distance of active opening varies between 40 and 50 mm.



Fig 4-5 Passive movement is obtained when the dentist forces the jaw to open beyond the active opening position.

history can identify the presence of pain as well as the mode of onset, site, characteristics, course, and variation over time.³² Localization and quantification of the pain can be made using schematic drawings of the face and body and asking the patient to indicate the areas affected. To establish the level of pain, a visual analog scale is used. Patients with TMD generally indicate a pain level between 3 and 5 on the scale. Pain symptoms are usually well correlated with functional activity; in these cases, a differential diagnosis can be made between myogenic pain and arthrogenic pain, because the first often radiates to a wide area and the latter is more localized.

Special attention must be paid to patients who report long-standing constant pain for which no treatment makes the pain increase or decrease. Chronic pain has a negative influence on cognitive-emotional states (health, outlook), behavior (exaggerated reactions), and social life (compromising relationships with family members, friends, and acquaintances). Thus, the longer chronic pain is reported to have persisted, the more important is a psychosocial evaluation in addition to the physical evaluation of the patient.

Given the multiple causes of orofacial pain, the case history is important for formulating a first diagnostic hypothesis of the quality, site, and history of the pain that must then be verified by clinical investigation.

Clinical examination

The clinical investigation starts with the first interview with the patient, through observation of the general state of health, facial expression, posture, and body language. The clinical examination checks for the presence of signs and symptoms of TMD through a quantitative and qualitative analysis of the

mandibular movements, palpation and auscultation of the TMJ, and palpation of the masticatory muscles. The examination is completed with an analysis of the maxillomandibular relationship and the occlusion (Fig 4-2).

Analysis of mandibular movements

Movements of the mandible can be studied by analysis of active and passive opening of the jaw, lateral movements, and protrusion. Active opening of the jaw is measured with a millimeter ruler between the edges of the maxillary and mandibular incisors, to which is added the overbite. The incisal margin of the maxillary incisors and the midline are marked in ink on the mandibular incisors (Fig 4-3). The physiologic value of the active opening varies between 40 and 50 mm (Fig 4-4); retrusion varies between 0 and 2 mm; protrusion varies between 6 and 9 mm; and lateral movement varies between 9 and 14 mm. The measurements are made after the patient has moved the jaw several times.

Passive movement is physiologically greater than active movement by 1 to 3 mm. The examiner obtains the measurement by manually forcing the jaw to open beyond the active opening position (Fig 4-5).

A qualitative evaluation of the mandibular movements is made by observing whether there is a deviation of the midline after several opening and closing movements. The correct relationship between the extent of maximum opening and the lateral movement is around 4:1. The probability that the measurement is reliable depends not only on the absolute value measured but also on whether the patient has recognized a reduction in the oral opening and whether this is accompanied by pain.

When the symmetry of the movements is considered, there

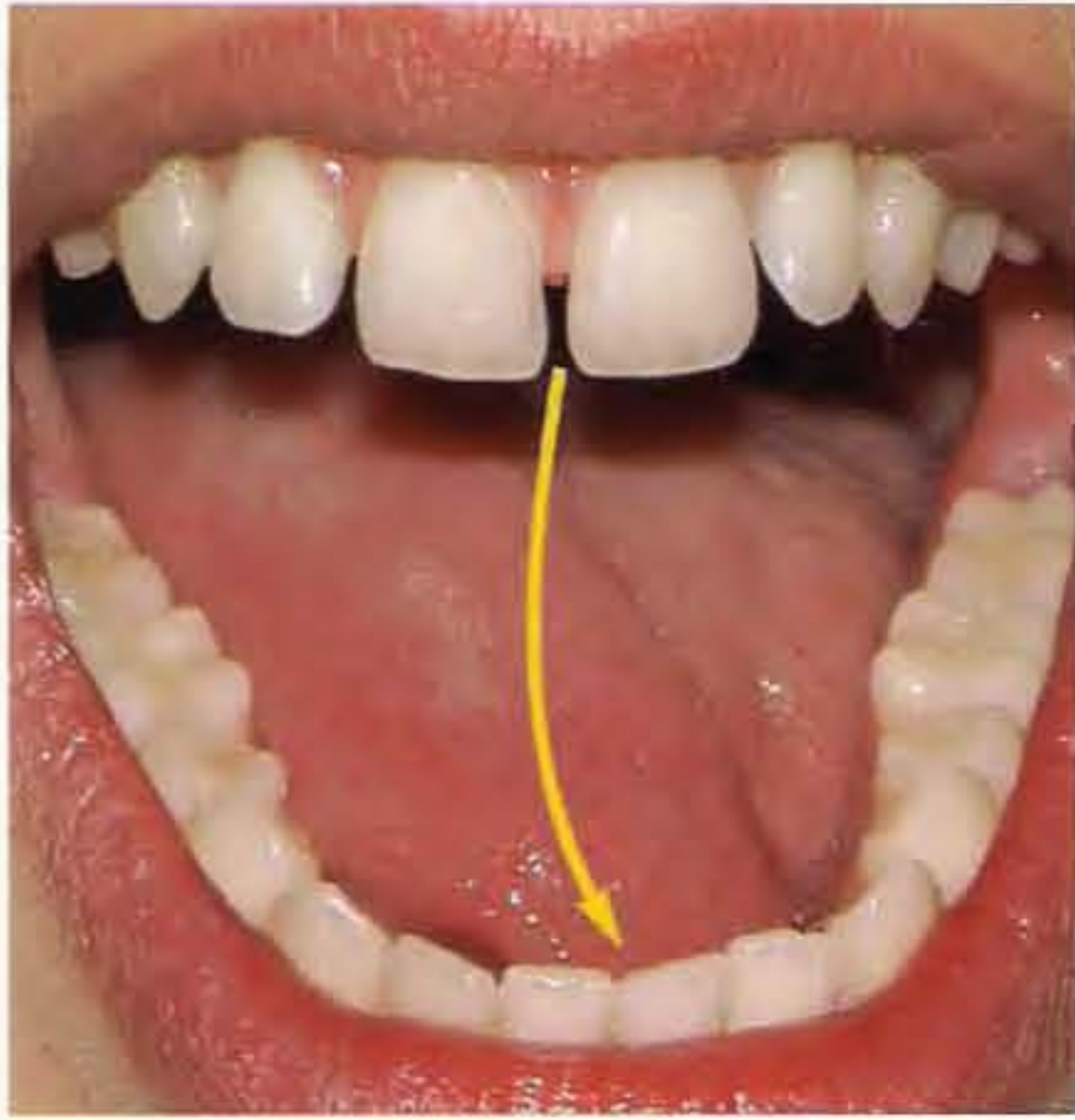


Fig 4-6 Deflection.

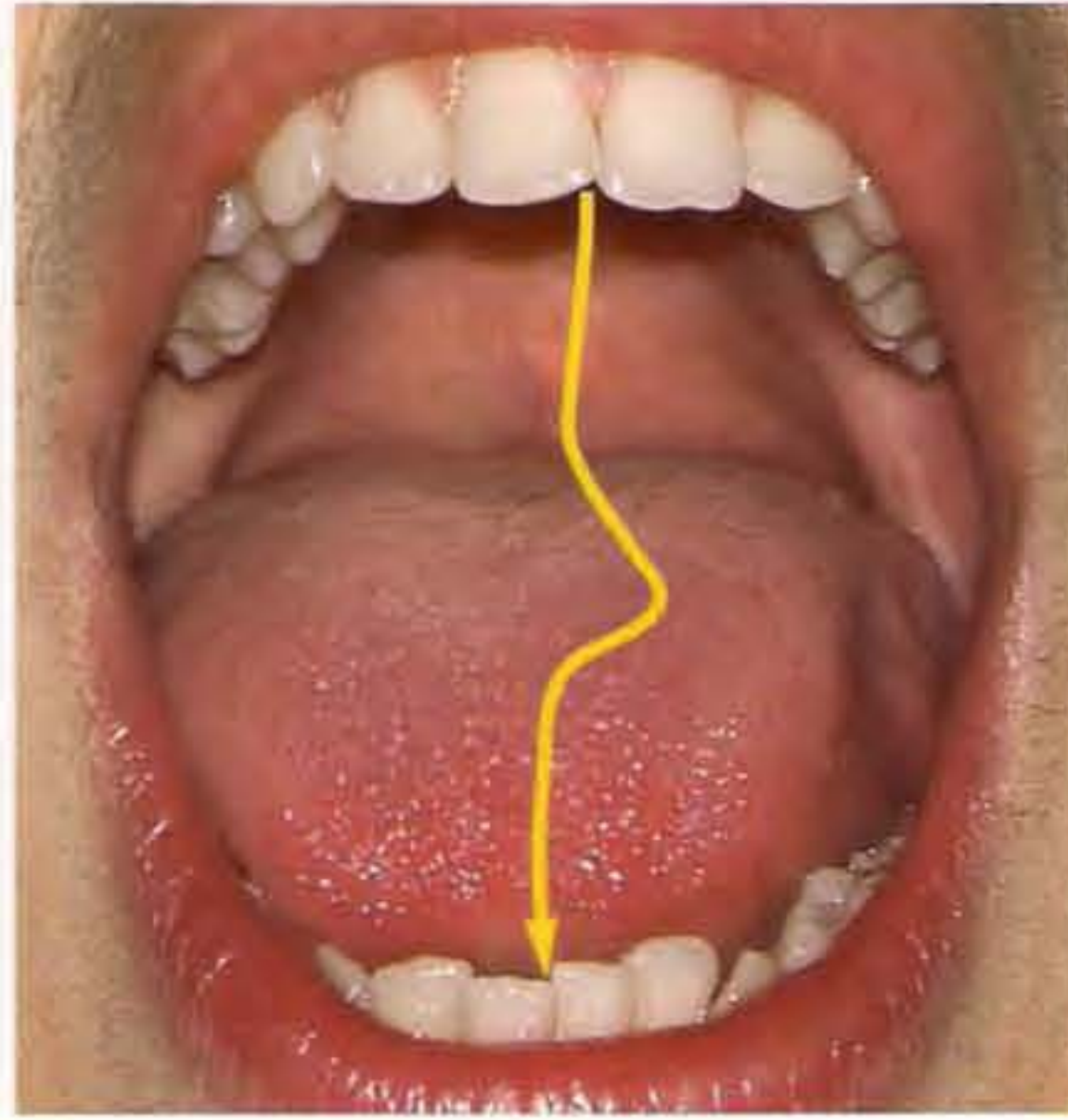


Fig 4-7 Deviation.



Fig 4-8 Endfeel.

may be deflection and deviation. Deflection is the movement of the median sagittal plane without return, measured from the mandibular interincisal point, during opening, closing, and protrusion (Fig 4-6). Deviation is the movement of the median sagittal plane with subsequent return to the same mandibular interincisal point during opening, closing, and protrusion (Fig 4-7).

Evaluation of Endfeel

The same movements used to measure opening and lateral movements are used to observe the terminal limit of movement and the objective sensation of elasticity or rigidity detectable by manually forcing the maximum opening or the active lateral movement (Fig 4-8). Physiologic endfeel is 2 to 3 mm without provoking pain. Further movements are impeded by the articular capsule and the ligaments. Pathologic endfeel is rigid (because of strong resistance that limits the movement, as with intra-articular problems, such as disc dislocation) or yielding and painful (if the patient reaches a maximum passive opening with painful masticatory muscles and a limited opening).

Joint play

This measurement requires forced movement of the TMJ while the patient's head is supported. The patient must be relaxed. The clinician holds the mandible with the thumb on the surfaces of the mandibular molars and the index and middle fingers under the chin arch and then moves the jaw downward, sideways, and forward, while placing the middle finger of the other hand on the TMJ being examined (Fig 4-9). Pain during the movement indicates an inflamed joint. A rough or uneven and irregular movement indicates osteoarthritis.

Tests of passive opening, endfeel, and joint play are difficult and not very reliable in patients with pain because of the opposing resistance of the muscles.

Auscultation of the TMJ

The examiner should first ask the patient if he or she hears noises in the TMJ and on which side. Then the clinician should listen to the TMJ as the patient opens and closes, in protrusion and lateral movements, using a stethoscope if needed (Fig 4-10). Noises of short duration, heard in various positions during the opening and closing of the joint (clicks), indicate a disc displacement with reduction. Rubbing or crepitus/rustling noises (like stepping on sand) are an indication of osteoarthritis. A small, soft noise heard at the end of opening indicates overextension past the articular eminence.

Palpation of the TMJ

Examination includes digital palpation of the both sides of the joint, laterally and posterior to the joint in maximum intercuspal position, during opening, closing, protrusive, and lateral movements (Fig 4-11). Palpation of the TMJ, if positive, does not constitute a diagnosis. It is only an indication of inflammation of the joint.

Muscular palpation

Palpation of the muscles should be made symmetrically and after all the other tests are performed, so that any pain experienced does not compromise the objectivity of the examinations. The clinician should start by showing the patient how to distinguish the difference between pain and a sensation of pressure (Fig 4-12). Muscles must be relaxed so that tension, the presence of hardened bands, and small areas of circumscribed pain (trigger points) can be identified. Pain during muscular palpation is always a valuable clinical sign that must be evaluated with other symptoms before a diagnosis of significant pathology is made. If at least three of the palpated areas are painful and at least one area is on the same side where the patient feels pain, the diagnosis probably will be oriented toward muscle pain (Figs 4-13 to 4-18).



Fig 4-9 Joint play.



Fig 4-10 Auscultation of the TMJ.



Fig 4-11 (a to c) Palpation of the TMJ.



Fig 4-12 Muscular palpation.



Fig 4-13 Palpation of the temporal muscles in the anterior, median, and posterior areas.



Fig 4-14 Palpation of the insertion of the tendons from the temporal muscles to the coronoid process of the mandible.



Fig 4-15 (a and b) Bidigital palpation, both superficial and profound, of the masseter muscle.



Fig 4-16 Palpation of the insertion of the median pterygoid muscles at the mandibular angle.

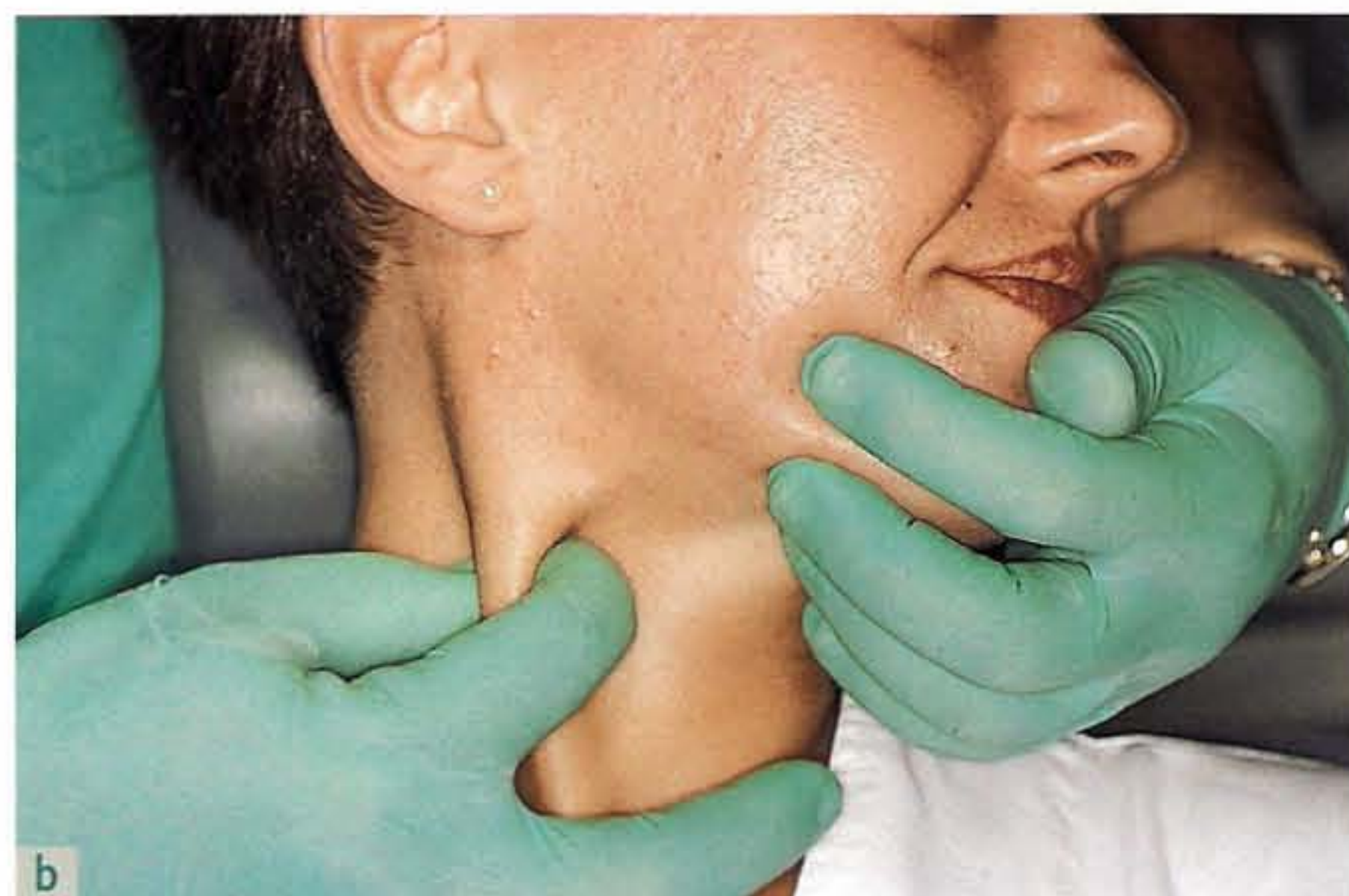


Fig 4-17 (a and b) Palpation of the three insertions and the belly of the sternocleidomastoid muscle.



Fig 4-18 (a and b) Palpation of the muscles of the neck, the nape, and the shoulders.



Fig 4-19 Mandibular manipulation using the Dawson method.

Analysis of maxillomandibular relationships

Manipulation of the mandible

Clinical analysis of the maxillomandibular relationships in various movements of the jaw starts with manipulation of the mandible. This is often difficult in patients with pathologic jaw pain, because of rigidity of the area. Therefore, the first action is a delicate maneuver to increase the relaxation of the muscles. This is followed by a firm grip to maintain the mandible and the disc-condyle complex in an easily reproducible position.

The mandible can be manipulated using several approaches; one of the most common is the Dawson method (Fig 4-19). This maneuver will indicate the various grades of movement of the mandible: easy, difficult, and impossible. If the mandible cannot be manipulated, occlusal analyses have no significance.

Relationship of intercuspal position (ICP) to retruded contact position (RCP)

If manipulation of the mandible is possible, starting from the position of maximum nonforced retrusion (the position in which lateral movements are possible; RCP), it is possible to check the sliding of the mandible from that position to one of maximum intercuspation (ICP). If the slide measures 3 mm or more, an indirect analysis in an articulator is needed to better evaluate the occlusal situation.

Direct occlusal analysis

The purpose of direct occlusal analysis is to evaluate the occlusion and other components of the oral cavity and jaw in both static and dynamic modes. This is needed before extensive occlusal rehabilitation; construction of a removable prosthesis; or orthodontic therapy and/or orthognathic surgery. Technically, static occlusal contacts are analyzed in the state of maximum intercuspation (ICP) and in centric relation (RCP), and dynamic

occlusal contacts are analyzed during lateral movements to the right and left and in protrusion, while a light contact is maintained between the teeth.

The first 2 to 3 mm of movement are significant. Contacts must be checked accurately with articulating paper. The clinician should look for guiding contacts on the working side (canine or group guidance); contacts on the nonworking side; and contacts in protrusion.

The examiner should register any gross interference that impedes such movements such as extruded, malpositioned, or missing teeth or a closed or open bite. Fractures, mobile teeth, and facets that indicate parafunction should also be noted (Box 4-5). Box 4-6 defines the relevant terminology for the occlusal analysis.

Instrumental functional analysis

If the functional analysis does not allow a diagnostic hypothesis to be reached, examinations using instruments can add further diagnostic elements.

The panoramic radiograph is most often used to provide a rough overview of possible pathologic alterations of the oral cavity and jaws.³³ In everyday practice, most patients are subjected to this kind of radiographic imaging. The use of other diagnostic methods (eg, magnetic resonance imaging, comput-

Box 4-5 Factors to note during occlusal examination

- Number of teeth in each arch; missing teeth (on one side only or bilaterally)
- Inclined or rotated teeth
- Morphology of the dentition
- Dental class and facial type
- Contacts in maximum intercuspation (ICP)
- Vertical dimension of occlusion (VDO):
 - Physiologic (TMJ in functional equilibrium)
 - Increased
 - Reduced
- Contacts in centric relation:
 - Premature contacts in centric relation
 - Centric stop
- Discrepancies between RCP and ICP at maximum intercuspation
- Maxillomandibular relationship in laterotrusion:
 - Balanced contacts
 - Working contacts
 - Hyperbalanced contacts
- Maxillomandibular relationship in protrusion:
 - Protrusive contacts
- Abrasion facets

ed tomography) may be indicated for confirmation of the diagnosis and treatment plan.

Instrumental registration of maxillomandibular relationships is made by mounting the casts in an articulator so that an indirect occlusal analysis can be made. This is used when the occlusal relationships are not detectable clinically or it is necessary to establish a maxillomandibular relationship that differs from the initial one.

Treatment of TMDs

Research on the treatment of these problems is characterized by a lack of prospective studies and random sampling with clear criteria for inclusion and exclusion of subjects and a lack of definition of therapeutic results. However, some patient management principles can be formulated. The objectives of treatment are to reduce pain, reduce the load of the masticatory system, and restore jaw function. From this point of view, early treatment is important to prevent problems from becoming chronic and to prevent the development of greater psychosocial problems (Axis II).³⁴

As already mentioned, there is growing evidence that the signs and symptoms of TMD are self-limiting and often can resolve without serious pathologic sequelae.^{16,17,20} As a consequence, the use of noninvasive and reversible techniques must be promoted rather than surgery and complex treatments. Conservative treatment has been demonstrated to reduce pain and dysfunction in between 50% and 90% of patients³⁵ and for long periods of time.¹⁷

The existing literature on treatment of TMDs clearly indicates that similar results are obtained with practically all treatments. This puts in doubt the etiologic or specific value of treatments and suggests rather that the placebo effect and time play fundamental roles. Some of the few randomized studies carried out indicate that biofeedback, antidepressants (amitriptyline) or benzodiazepines (clonazepam), and acupuncture are more effective than placebos.³⁶ On the other hand, validation of the use of occlusal appliances, nonsteroidal anti-inflammatory drugs, muscle relaxants, and various modes of physical therapy³⁷ is still missing.

When disc displacements are considered, the position of the articular disc is not correlated to development of pain,¹⁹ and a disc displacement with reduction does not necessarily progress to a closed lock.^{16,17}

For these reasons, intraoral appliances and surgical techniques aimed at repositioning the disc do not have a significance for etiologic therapy and have demonstrated only a moderate level of success in stabilizing the disc position and preventing clicking noises of the joint.³⁸

Box 4-6 Definition of terms

- **Working side (or lateral movement or laterotrusion):** The side toward which the mandible moves in a lateral excursion. If the mandible moves to the right, that side is considered the working side.
- **Nonworking side:** The side opposite the working side; that side of the mandible that moves toward the midline in a lateral excursion. Thus, if the mandible moves toward the right side, the left side of the dentition is considered the nonworking side.
- **Premature contact:** An undesirable occlusal contact prior to intercuspation (the interdental contact that happens before the maximum intercuspation during the closing movement of the jaw).
- **Interference:** Dental contact that happens during eccentric movement of the mandible that modifies the trajectory of the mandibular movement.
- **Working-side interference:** A contact that interferes with uniform sliding movements. Interferences are considered the one or two contacts on the posterior teeth of the working side in the absence of canine guidance.
- **Nonworking-side interference:** Contacts between teeth on the nonworking side that cause disclusion of the teeth on the working side. When a dentate person makes a lateral movement of the jaw, and canine guidance or group function is not able to obtain the immediate disclusion of the teeth on the opposite side, but, simultaneously with contacts on the working side, there are one or more contacts on the nonworking side, it is called *nonworking-side interference*. If the teeth on the nonworking side impede contacts on the working side, this is called *hypercompensating interference*.
- **Deflective occlusal contact:** A tooth-to-tooth contact that changes the direction of mandibular movement during closure.
- **Working-side contacts:** The contacts between maxillary and mandibular teeth or denture bases on the working side, or anteriorly in a protrusive occlusion.
- **Nonworking-side contacts (balancing contacts):** The contacts between maxillary and mandibular teeth or denture bases on the nonworking side, or posteriorly in a protrusive occlusion.
- **Orthocompensating/hypercompensating contacts:** Working-side contacts and nonworking-side contacts can be identified using colored articulation paper (to give an overall idea of the orientation). To differentiate between orthocompensating and hypercompensating contacts, it is necessary to use shimstock foil (8- μ m). After the working side is identified, the shimstock foil is placed between the teeth on the nonworking side; if the foil can be removed with little resistance, this is an orthocompensating-type contact. If the foil cannot be pulled out from the teeth, this is a hypercompensating-type contact.

In conclusion, based on the small amount of adequately qualitative data available, conservative, noninvasive, and reversible therapy seems most appropriate for the majority of patients. The rest of this chapter summarizes the general characteristics of such therapy. Irreversible occlusal treatment and prosthetic reconstruction do not have a role in the prevention or treatment of TMD. In a patient with TMD who needs extensive prosthetic treatment, this must be provided only after a remission of the signs and symptoms, obtained by reversible therapy.

Patient education and reassurances

A simple conversation with the patient about the benign and self-limiting character of the disease may immediately have a therapeutic effect. The patient can learn that the disorder is not uncommon, not serious, and not incurable and that the success of treatment is partially in his or her hands. The patient must also be made aware of his or her own oral bad habits and be trained to recognize the possible relationship with stress. External reinforcement received several times a day can be useful, such as visual and auditory reminders (eg, memos on sticky notes or telephone calls). The patient must use self-observation for each stimulus, through which he or she can recognize clenching of the teeth and learn to knowingly and voluntarily relax the masticatory muscles. Having the patient record the symptoms in a daily diary may also be useful.

This type of discursive approach with the patient may include discreet but specific interviews of other people in the patient's personal, family, and work environment.

Techniques for self-control

Numerous techniques of muscle relaxation exist:

- Progressive relaxation
- Biofeedback
- Techniques for control of breathing
- Yoga
- Autogenous training and simple forms of psychoregulation
- Hypnosis

Neuromuscular relaxation³⁹ tends to reduce tension in the muscle mass, based on the patient learning to perceive his or her own tension. The muscles involved must be tensed and then relaxed isotonicity and isometrically. Breathing rhythm must be tranquil and regular. Success is linked to perseverance in the practice.

With biofeedback,⁴⁰ the patient is able to consciously control physical and psychological processes that are normally autonomous and unconscious. Using a special apparatus, the

patient becomes aware of the level of tension in the muscles through visual and auditory signals. With this information, the patient can learn self-control.

With the method of respiratory regulation,³⁹ muscular tension is controlled through improvement of respiratory function. The patient practices regular respiration at the diaphragm level; tension is created on inspiration and eliminated at the expiration, followed by a brief pause.

Yoga,³⁹ a Hindu philosophy originally practiced by ascetics, proposes physical and mental health through stimulation of particular states of consciousness, distension, interior illumination, and consequent control of psychological burdens. Through gymnastic positions, immobility, controlled, and rhythmic respiration, the practitioner acquires training in self-control of thoughts and will.

Autogenous training⁴¹ is a technique of self-relaxation. It is achieved through passive mental concentration managed by the patient and can positively modify muscular tension in a progressive way. It is divided into two phases: In the first inferior or physical phase, completely autogenous, the mental concentration is directed toward emerging sensations to physical modifications; in the second superior or psychic phase, the patient is oriented toward a psychic and emotional life.

If the original mechanism attributed to these techniques was generally known as *reduction of systemic burden*, it is evident that they have common characteristics that are active at the level of Axis II.

Pharmacologic therapy⁴²

The drugs most often used are nonsteroidal anti-inflammatory drugs, which are most useful in patients with active articular disease to control pain and prevent the problems from becoming chronic. Less use is made of antidepressants, benzodiazepines, and other drugs affect the central nervous system (CNS), at least in nonchronic situations. However, in chronic cases, pain can become incapacitating, often with comparatively mild pain. Many patients with chronic problems are beyond the help of a dentist and request specialist and multidisciplinary care.

Physiotherapy^{43,44}

Physiotherapy is used to control pain and to increase the range of movements of the jaw. There are various types of physiotherapy: heat therapy, cold therapy, electrotherapy, massage therapy, and kinesiotherapy. Some therapies can be used directly by the patient after instruction and training.

Occlusal therapy

In patients who have TMD and are in need of occlusal restoration (for strictly dental considerations), placement of a provisional prosthesis is an obligatory step in prosthetic rehabilitation. This permits the reevaluation and reconsideration of the therapeutic plan; the definitive prosthesis can only be made when the patient is not in pain. There is no scientific justification for permanent modification of the occlusion as therapy for TMDs, and therefore it must not be used in this way.

Splint therapy^{45–47}

Many occlusal splint designs have been proposed, and none has undisputable scientific backing or has been judged clearly superior to others. The following sections will describe the construction and use of the Michigan occlusal splint (Fig 4-20) because of its simplicity, its range of indications, and its familiarity worldwide. The phases of laboratory construction of a Michigan splint are described in detail, because dental technicians usually have less information about and experience with this type of appliance than other, more common prostheses (eg, complete and partial prostheses, both removable and fixed).

Characteristics of a Michigan splint⁵ (Fig 4-21)

The occlusal surface is flat and polished.

- It has point cuspal contacts for all teeth (large areas of contact are not desirable because these may cause new parafunctional problems).
- The resin splint covers all the teeth of the maxillary arch.
- The palatal extension reaches the dental equator.
- The vestibular length is 1 to 2 mm.
- The centric contacts are not positioned on the inclined plane (but rather orthogonal to the surface of the splint).
- The splint has a slight palatal inclination in the incisal area, to allow axial contacts in case of proclination of the mandibular incisors.
- The frontal plane extends 1 mm dorsally at the contact point of the mandibular incisors.
- There is freedom in centric relation (comfortable space of 0.5 × 0.5 mm from ICP to RCP).
- Canine guidance is provided in protrusion and laterally.
- The splint has a horizontal plane of 0.5 × 0.5 mm preceding the canine guidance to permit freedom in centric relation before disclusion.
- The increase in the vertical dimension is limited, so that it will interfere as little as possible with oral functions (Fig 4-22).
- Posterior disclusion should be about 2 to 3 mm (Fig 4-23).

The materials used to fabricate a Michigan splint are listed in Box 4-7.



Fig 4-20 Michigan splint.

Box 4-7 Materials for preparation of a Michigan splint

- Articulator
- Hard plaster for stone casts
- Plaster to prepare articulating bases
- Cutter
- Red modeling wax (of medium hardness)
- Extra-hard wax (for canine guidance)
- Wax knife
- Wax spatula (Lecron)
- Fine pencil (0.5-mm point)
- Telephone card
- Talcum powder
- Petroleum jelly
- Adhesive tape
- Insulation for wax and plaster
- Articulating paper (40-μm thick), in two colors
- Cylindrical bur
- Medium conical bur (for canine guidance)
- Pumice and polishing paste
- Transparent resin
- Surveyor
- Flasks, flask holder, hydraulic press, and pressure cooker

Guidelines for the construction of a Michigan splint

The splint should be of minimum size (crown on crown). The dental contact area should be isolated from the rest of the masticatory system. The splint must not introduce new, harmful interferences. It should cause minimum interference with the labial seal, phonation, and deglutition. The laboratory procedures are described in Box 4-8.

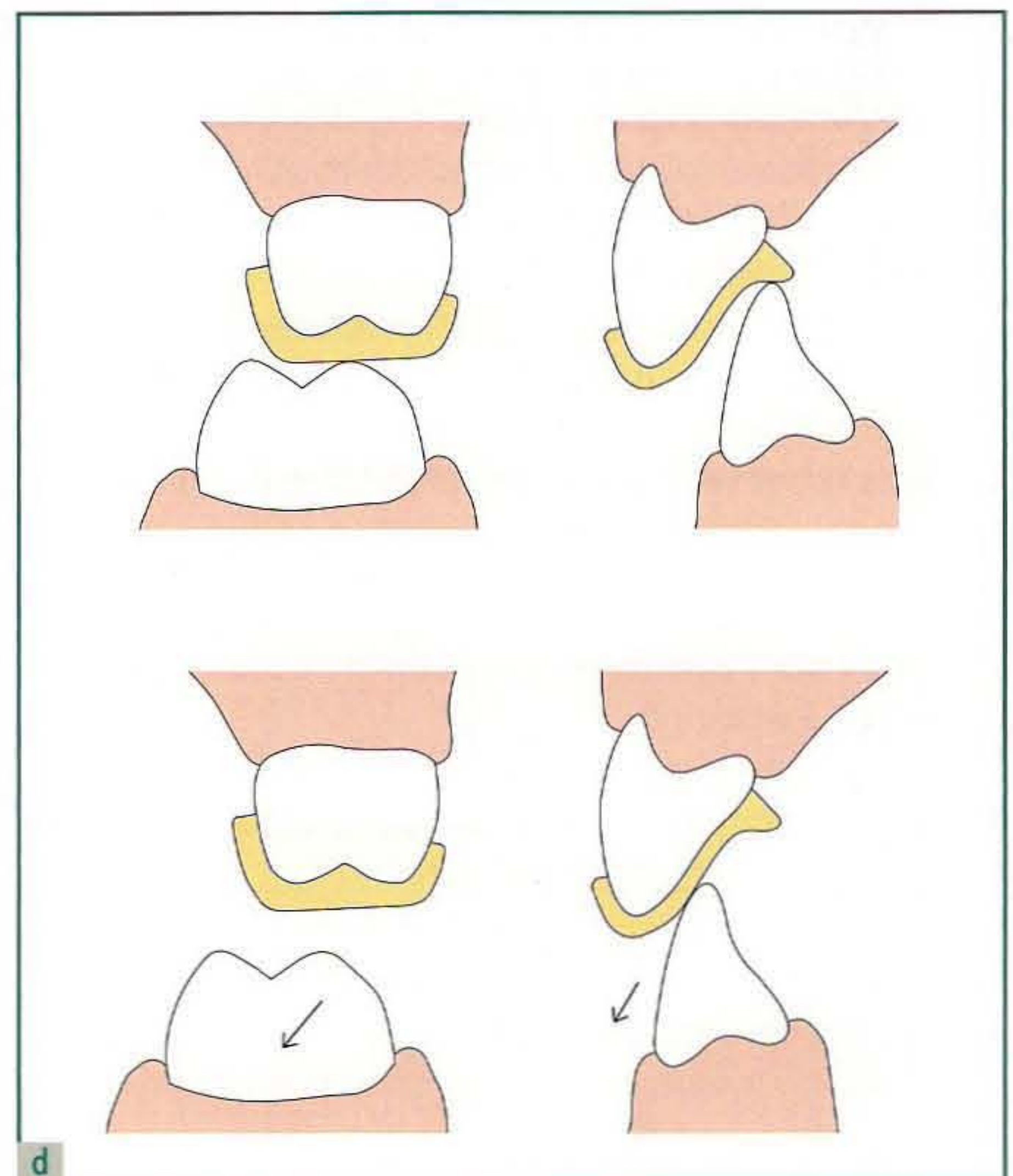
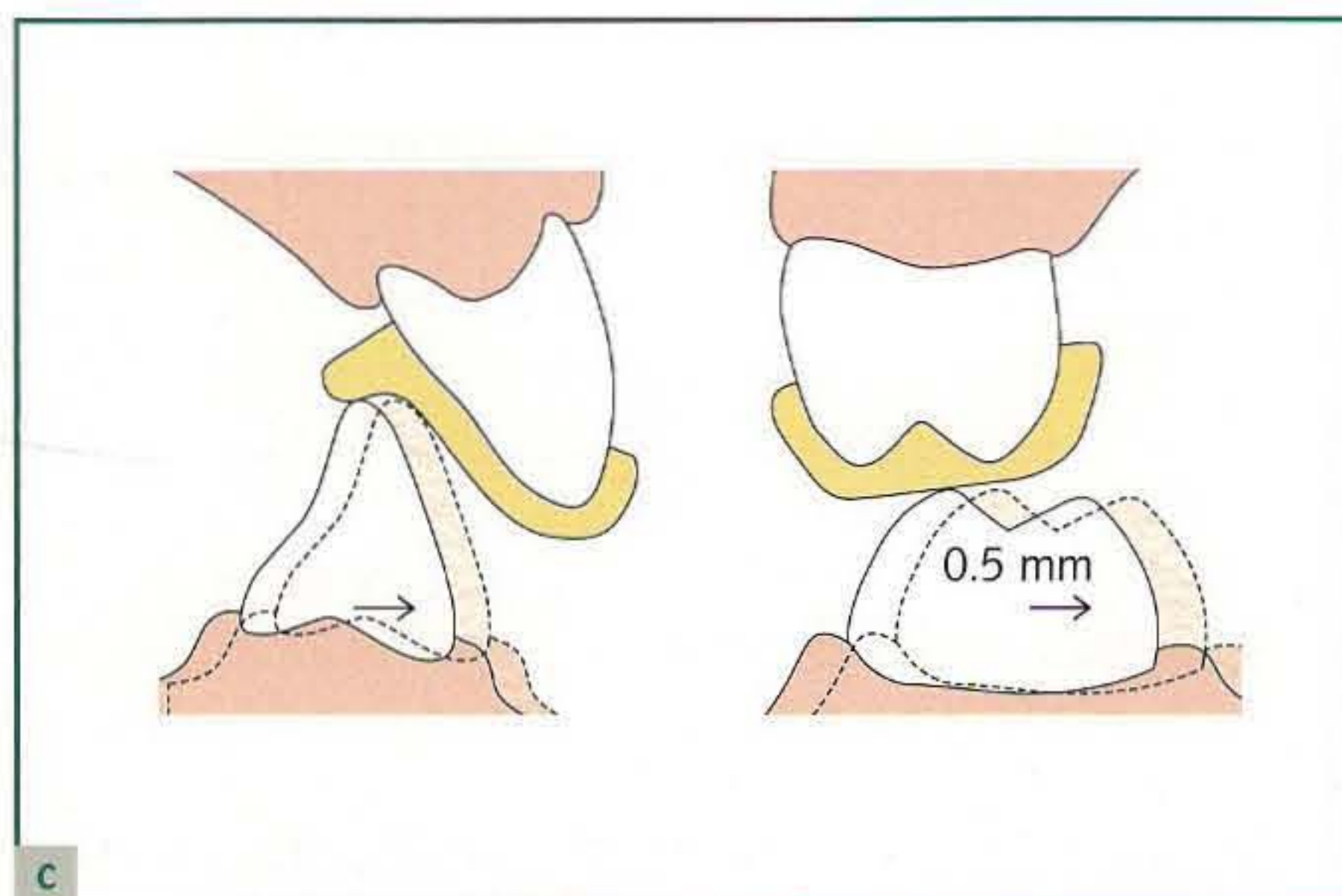
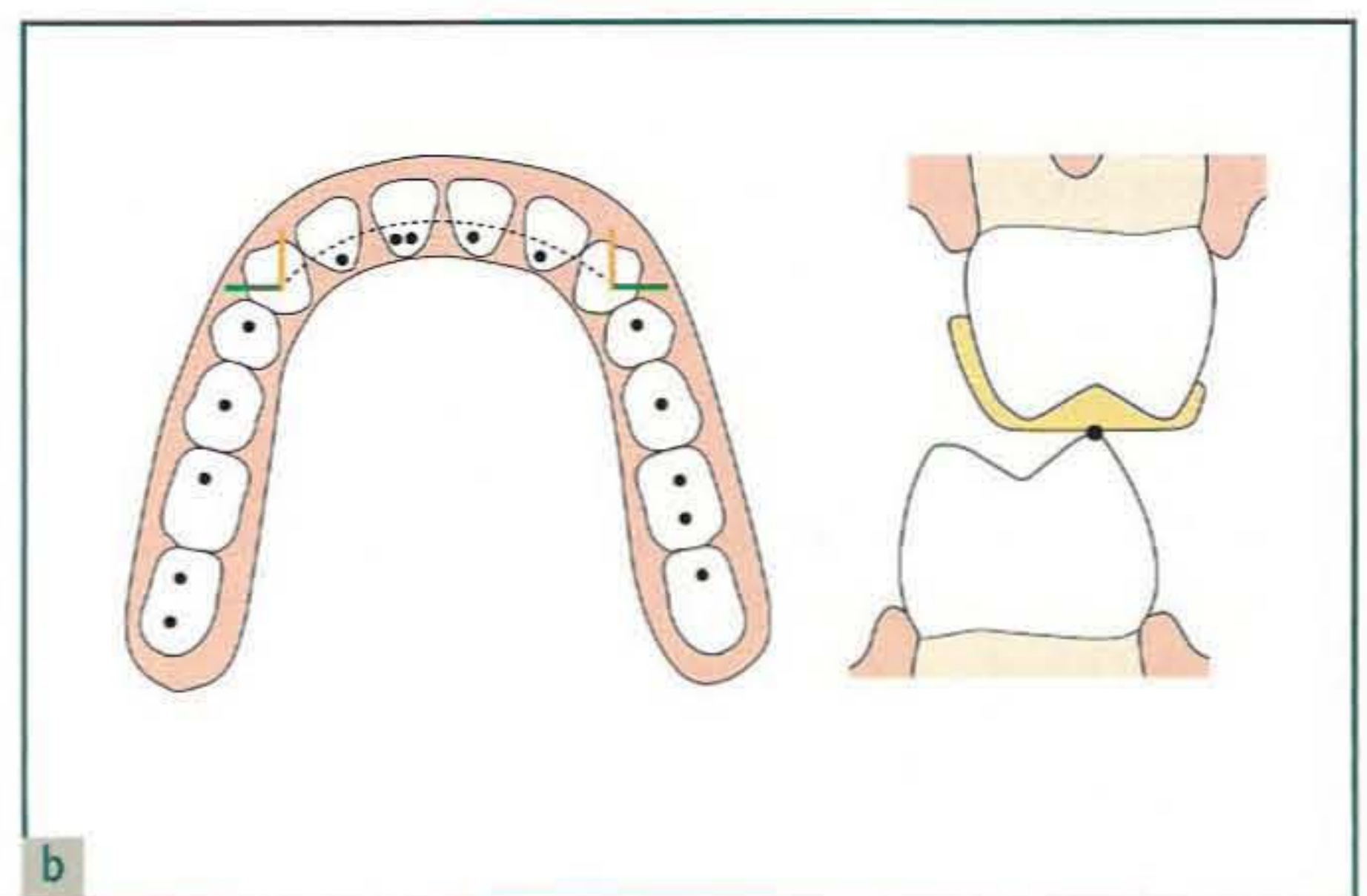
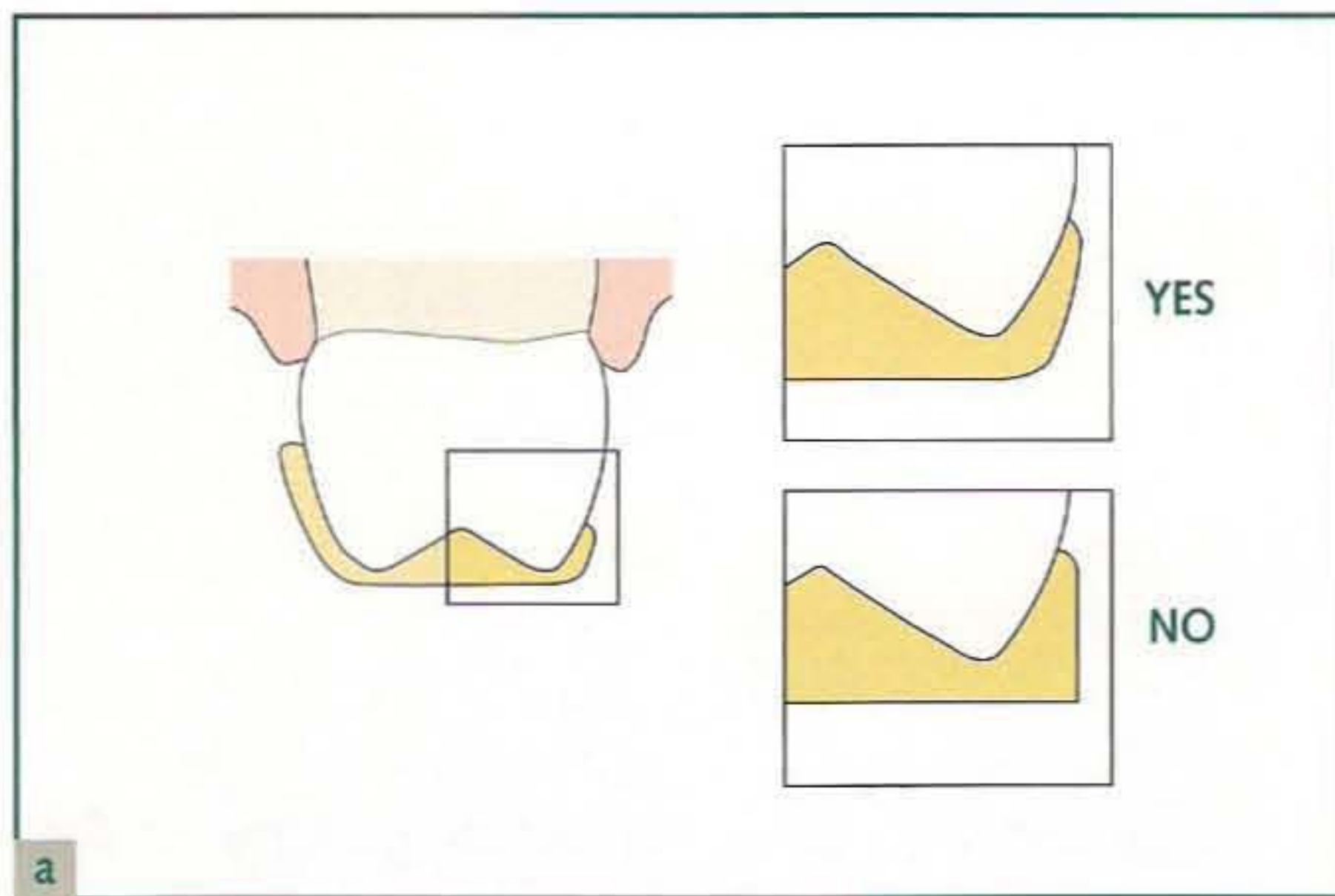


Fig 4-21 (a to d) Construction characteristics of the Michigan splint (see text for a description). (a) Angles should be smooth. (b) There are point cuspal contacts (black dots) for all teeth. (c) Freedom in centric relation is provided by a comfortable space of 0.5 x 0.5 mm from ICP to RCP. The frontal plane extends 1 mm dorsally at the contact point of the mandibular incisors. (d) Cuspal contacts for all teeth in ICP and RCP (top). Canine guidance is provided in protrusion and laterally (bottom). Posterior disclusion should be between 2 and 3 mm (arrows). Protrusive and lateral movement of the mandible.



Fig 4-22 The increase of the vertical dimension of occlusion is limited, so as to interfere as little as possible with oral functions.



Fig 4-23 In the edge-to-edge situation between canines and the top of the guide, the posterior disclusion must be about 2 to 3 mm.

Box 4-8 Laboratory procedures for fabrication of a Michigan splint**1** *Preparation of the stone casts*

- Prepare⁶ split casts in hard plaster.
- Duplicate the master cast.
- Ensure the convergence of the axial walls of the casts.
- Check that the cast can fit into the flask furnace.

2 *Use of the surveyor and removal of undercuts*

- Draw the dental midline with the surveyor.
- Block any sulci, interdental spaces, and undercuts that are too deep to prevent polymerization contraction of the resin.

3 *Establishment of the relationship between the casts in the articulator*

- Mount the casts in the articulator.
- Adjust the incisal axis to zero in the articulator.
- Seat the reproducing elastic of the Bonwill triangle.
- Place the casts in ICP with the plaster keys.
- Raise the incisal axis to obtain a 1-mm separation of the molars (use the telephone card to indicate the space needed).

4 *Waxing of the Michigan splint*

- Heat a sheet of wax and adapt it to the palatal and occlusal surfaces.
- Alternative method: Form the wax sheet around the dental arches and add the melted wax drop by drop.
- Isolate the occlusal surfaces of the mandibular cast.
- Open and close the articulator several times.
- Model the surfaces of the occlusal table to be as smooth as possible.
- Extend the palatal surface to the equator and vestibule 1 to 2 mm beyond the incisal margin.
- Slightly incline, in the palatal direction, the guide plane

of the incisal area (to allow orthogonal contacts with proclined mandibular incisors).

- Extend the frontal plane dorsally by at least 1 mm beyond the habitual contacts.
- Check the cuspal contacts of all teeth with 40- μ m articulating paper.
- Model the canine guidance: inclined planes that will create lateral and protrusive guidance.
- Create a horizontal plane of 0.5 x 0.5 mm that precedes the canine guidance to allow freedom in centric relation.
- In edge-to-edge positioning between the mandibular canine and the top of the guide, the posterior disclusion must be 2 to 3 mm.
- Polish the surfaces with soap and special varnish.

5 *Placing the casts in the duplicating flask*

- Carefully isolate the cast.
- Fill the plaster cast.
- Isolate it after hardening.
- Fill the counter cast with plaster.
- Close the flask and place it in boiling water.
- Open the flask and remove the melted wax.
- Isolate the cast and counter cast.
- Mix the resin and place it in the flask.
- Close the flask and press it.
- Wait for polymerization and remove the casts, opening the flask delicately to avoid cracks.

6 *Polishing and finishing of the splint*

- Mount the cast in the articulator for occlusal corrections.
- Finish with low speed.
- Reestablish the contact of the incisal axis.
- Polish with pumice powder and polishing paste.

Indications for a mandibular Michigan splint

- Angle Class II molar relationship (subdivision 2)
- Accentuated curve of Spee
- Accentuated deep bite
- Absence of mandibular canines

Efficacy of and indications for the Michigan splint

The Michigan splint reduces asymmetry in the muscular activity. The signs and symptoms of TMDs are reduced during the therapy with the splint but may reappear after interruption of treatment.⁴⁸ The use of an occlusal splint reduces the pain, muscular tiring, and limitation of mouth opening.⁴⁹ A splint of

soft resin does not seem to reduce the muscular activity with the same effectiveness as a splint constructed of hard resin.⁵⁰ Activity of the masseter and temporal muscles, electromyographically recorded, is reduced after the use of an occlusal splint.⁵¹

The Michigan splint has positive effect over the short term (3 months) on muscular pain and in minor measures of articular pain.⁵²

However, consensus is lacking regarding the mechanism of the action of canine guidance; there do not seem to be clinical differences compared with group function guidance. The canine guidance on the splint produces an increase of activity in some muscles and a decrease in others.^{53,54}



Fig 4-24 Try-in to ensure that the positioning of the splint is correct.

The Michigan splint is a reversible, conservative, minimally invasive, easy to prepare, and low-cost means of therapy.^{55,56} Consequently, occlusal therapy with a Michigan splint is indicated for dysfunctional patients with either muscular or articular problems. For dysfunctional patients who need prosthetic restoration, the splint is indicated in the preliminary or provisional phase; during the restoration; and after the completion of the restoration. Before an extensive prosthetic restoration, occlusal therapy with a splint is used to induce muscular relaxation, to create an acceptable level of mandibular manipulation, and to reduce or avoid damaging parafunction. During an extensive prosthetic restoration, it enables an evaluation of the clinical changes, thus limiting errors, because it is reversible and simple to use and can be combined with other principal therapies. After an extensive prosthetic restoration, a splint may play a protective role for the actual rehabilitation.

Clinical verification of the Michigan splint

Precision

The dentist should ascertain that the position of the plate (Fig 4-24) is correct and the patient does not feel tension on any tooth. Pressure is applied to the occlusal surface and the canine guidance to check the stability of the plate. If there is any movement, a cold rebasing should be made; it is preferable to repeat the procedure from the beginning. It is only possible to make very slight adjustments to the premature contact points when the undercuts of the cast have been too little removed, thus impeding optimal insertion.

Retention

In the presence of excessive retention, it is useful to check the extension of the vestibular border and the interdental septa. When the splint is retained poorly, the vestibular border must be lengthened.

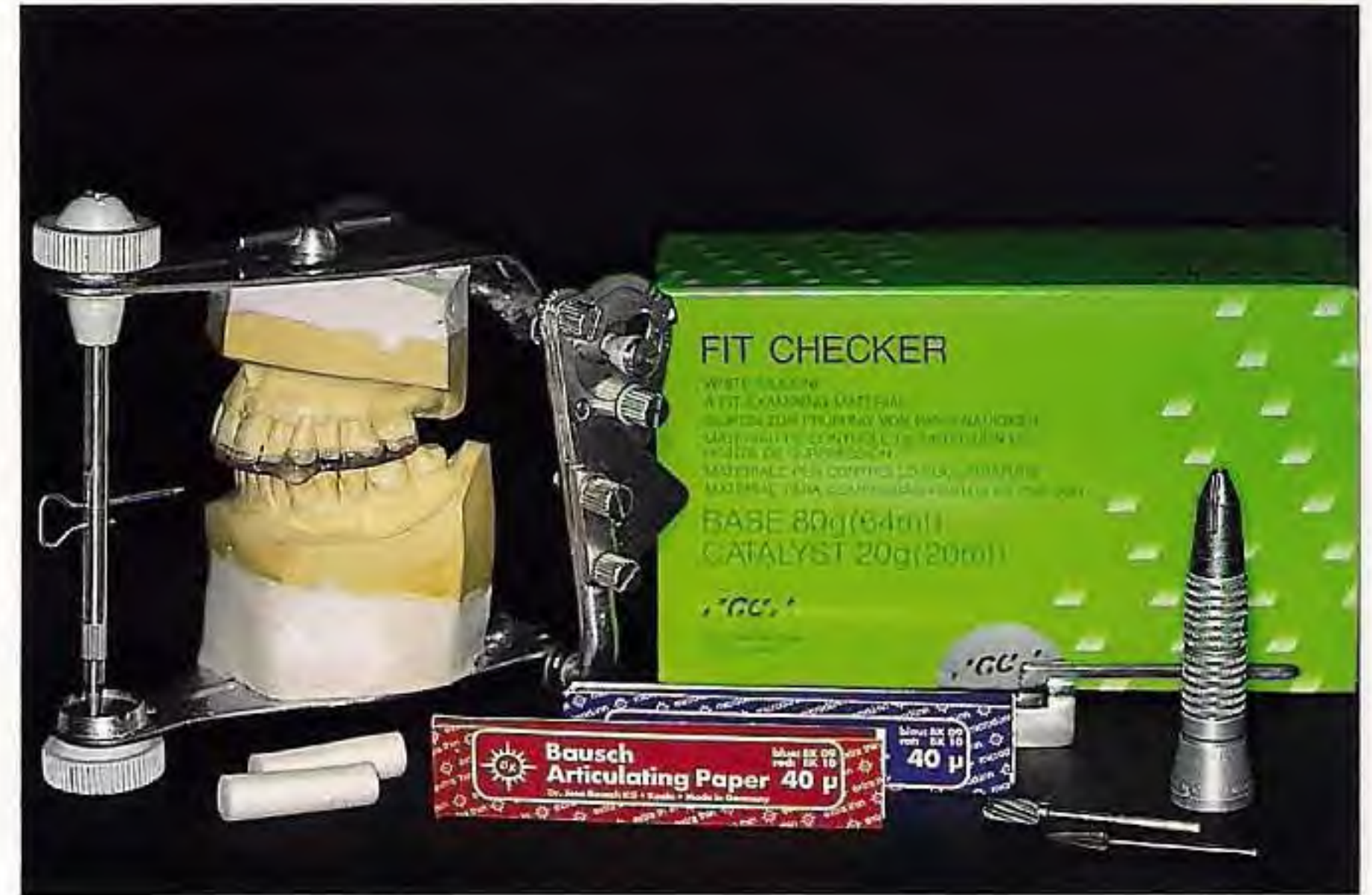


Fig 4-25 Materials for occlusal examination of the Michigan splint.

Grinding

Grinding may be necessary to ensure a freedom in centric relation of 0.5×0.5 mm and a canine guidance in protrusion and lateral movements. The occlusion can be checked with 40-µm-thick articulating paper in two colors (Fig 4-25). The occlusal control must ensure that every tooth has a cuspal contact on a smooth, flat surface and not on an inclined plane. Contact areas that are too large must be avoided.

The patient should be asked to close the jaws without excessive force. Cylindrical burs held parallel to the occlusal plane are used for all the occlusal surfaces that must remain flat.

Besides contact points that are visually homogenous, another guiding parameter is the sensation of the patient that the contact points are uniform as he or she is requested to slowly close the mouth. Initially, the patient must be seated with the head erect and leaning on the headrest of the dental chair. After the first examinations in this position, occlusal checks must be made while the patient makes various flexing and extending movements of the head, to test in all positions and to verify the freedom in centric occlusion during the passage from RCP to ICP (Fig 4-26).

To achieve control of the canine guidance (Fig 4-27), a long conical bur is used. The guide must have an inclination that allows disclusion at the premolars and molars in laterotrusion, always respecting the rule of freedom in centric relation. This can be obtained by noting the marks of the articulating paper on the splint while the patient makes complete movements, flexing and extending the head. Adjustments are made always with the bur held parallel to the inclined plane.

In edge-to-edge contact between the mandibular canines and the top of the splint guide, posterior disclusion must be between 1 and 3 mm. Lateral and protrusive movements made with the articulating paper in place will result in a V-shaped mark on the splint, made by the mandibular canine.

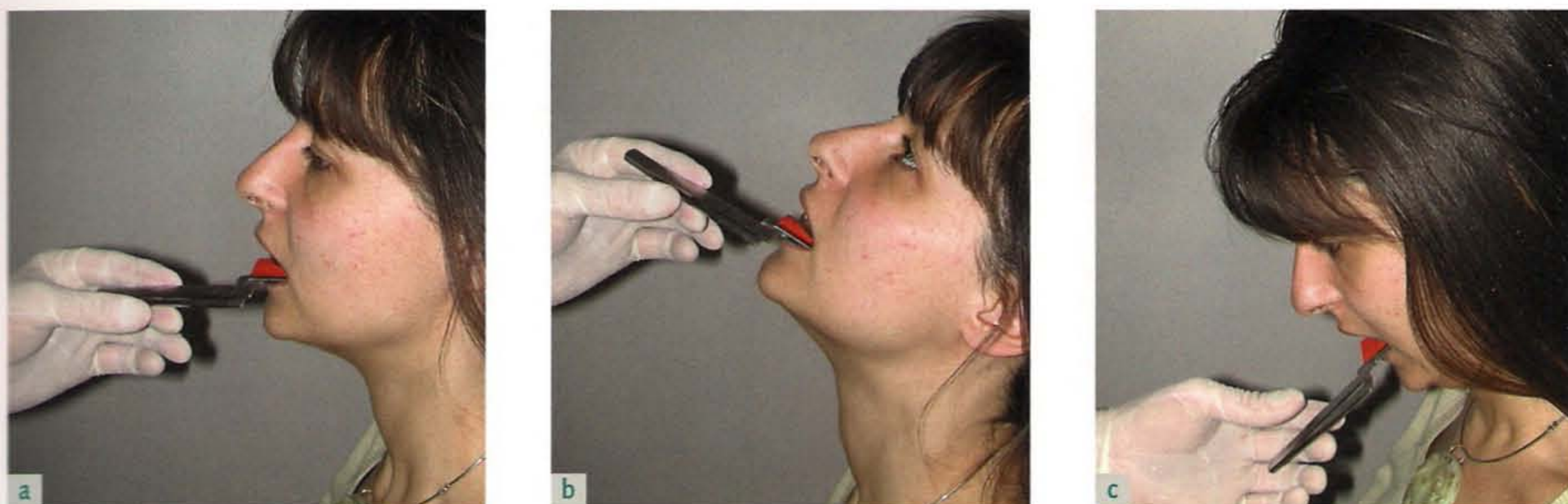


Fig 4-26 (a to c) Extension-flexion of the head is used to reproduce different postural conditions.

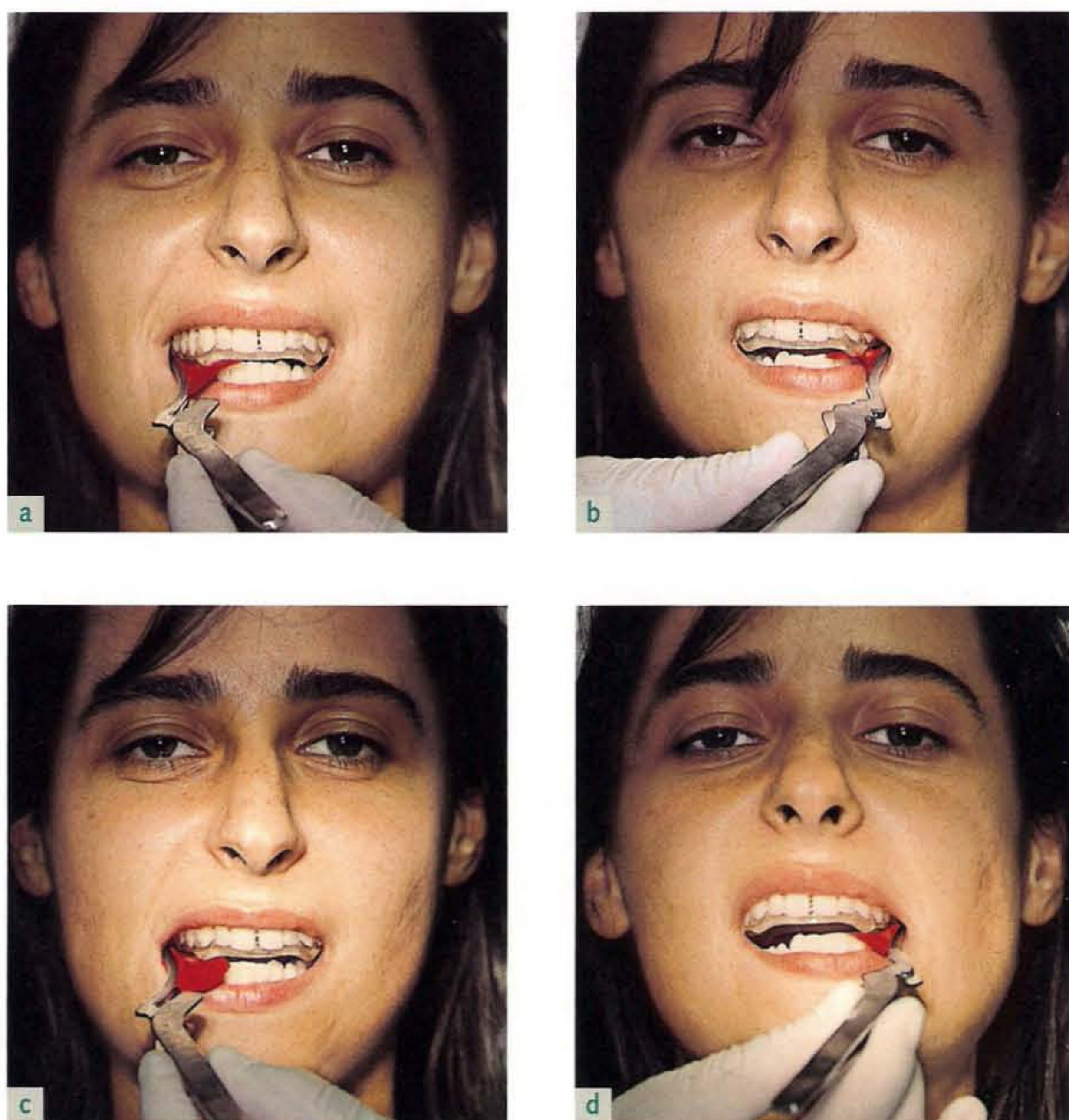


Fig 4-27 (a to d) The canine guidance is confirmed.



Fig 4-28 Delivery of the Michigan splint.

At the end of these occlusal examinations, the plate is polished carefully with a brush, pumice powder, and polish so as not to eliminate the contacts.

Patient instructions

The patient must be instructed about the importance of wearing the appliance at night and during the day as necessary. Toothbrushing is essential. The plate should be soaked twice weekly in a sodium hypochlorite solution and twice weekly an anticalcium solution, such as white vinegar (Fig 4-28).

Follow-up examinations

Follow-up should be made on days 1, 3, and 7 after placement of the splint and then regularly for 3 to 6 months. Such examinations must be made in a consistent way, with the first examination made between the first and seventh days, depending on the gravity of the problem.

For the subjective assessment, the dentist asks questions while the patient is wearing the appliance, noting the phonation; this permits an evaluation of the subjective adaptation. The patient should be asked when he or she has worn the splint, if the cleaning instructions have been followed, and if the symptoms have changed. The patient should then remove the splint so that the clinician can determine how the teeth occlude.

For the objective assessment, the movements of the mandible are evaluated through manipulation. The examiner should inspect the splint; assess the canine guidance and

occlusal contacts; look for signs of fracture of the appliance (caused by parafunctional movements), traces of wear such as indentation or erosion, and possible cracks; and observe the cleanliness of the plate.

Duration of therapy.

The splint should be worn until the signs and symptoms of TMD disappear and normal mobility and manipulability of the mandible are recovered. If the signs and symptoms last beyond a reasonable time, it is necessary to reconsider the diagnosis.

Selective grinding

Selective grinding is defined as modification of the occlusal shape to equalize the occlusal loads, produce symmetrical occlusal contacts, or harmonize intercusp relationships. Selective grinding is a nonreversible technique and must only be used in clearly defined cases. It is used to establish correct relationships between the jaws (mandibular stability) without premature contacts or interference. It is also used to treat cases of occlusal trauma.

It is indicated for slight alterations in the maxillomandibular relationships. Compared with orthodontic therapy for the same situation, it is low cost and is not time consuming. During prosthetic rehabilitation with a provisional prosthesis, it is fundamental to obtain occlusal adaptation. Selective grinding is contraindicated if the mandible cannot be manipulated, when there is pain, if there is loss of the VDO, and when the patient indicates little interest in the treatment and is not cooperative.

The control of the VDO during the grinding can only be made in an articulator (indirect occlusal analysis). The rule to be observed is an occlusal morphology that permits freedom in centric relations.

Clinical method to determine maxillomandibular relationships

Use of a facebow is obligatory. The casts are mounted in the articulator, and indirect occlusal analysis (Fig 4-29) is performed. After the ring nuts of the articulator are released (Fig 4-30), the rod is raised and maximum intercusp position is determined (Fig 4-31). The rod is lowered to the VDO of maximum intercusp position (Fig 4-32), and the cap is adjusted. The operative margin is indicated by the incisal rod, and the difference between the first contact and the position of maximum intercuspation is noted (Fig 4-33).

When the incisal rod comes into contact with the cap before the grinding has been completed, mandibular stability must be improved by additive techniques (crowns or inlays). Continuation of the selective grinding will result in a loss of the VDO. The controlled inspection of the VDO is the most important reason for not performing selective grinding directly in the mouth.

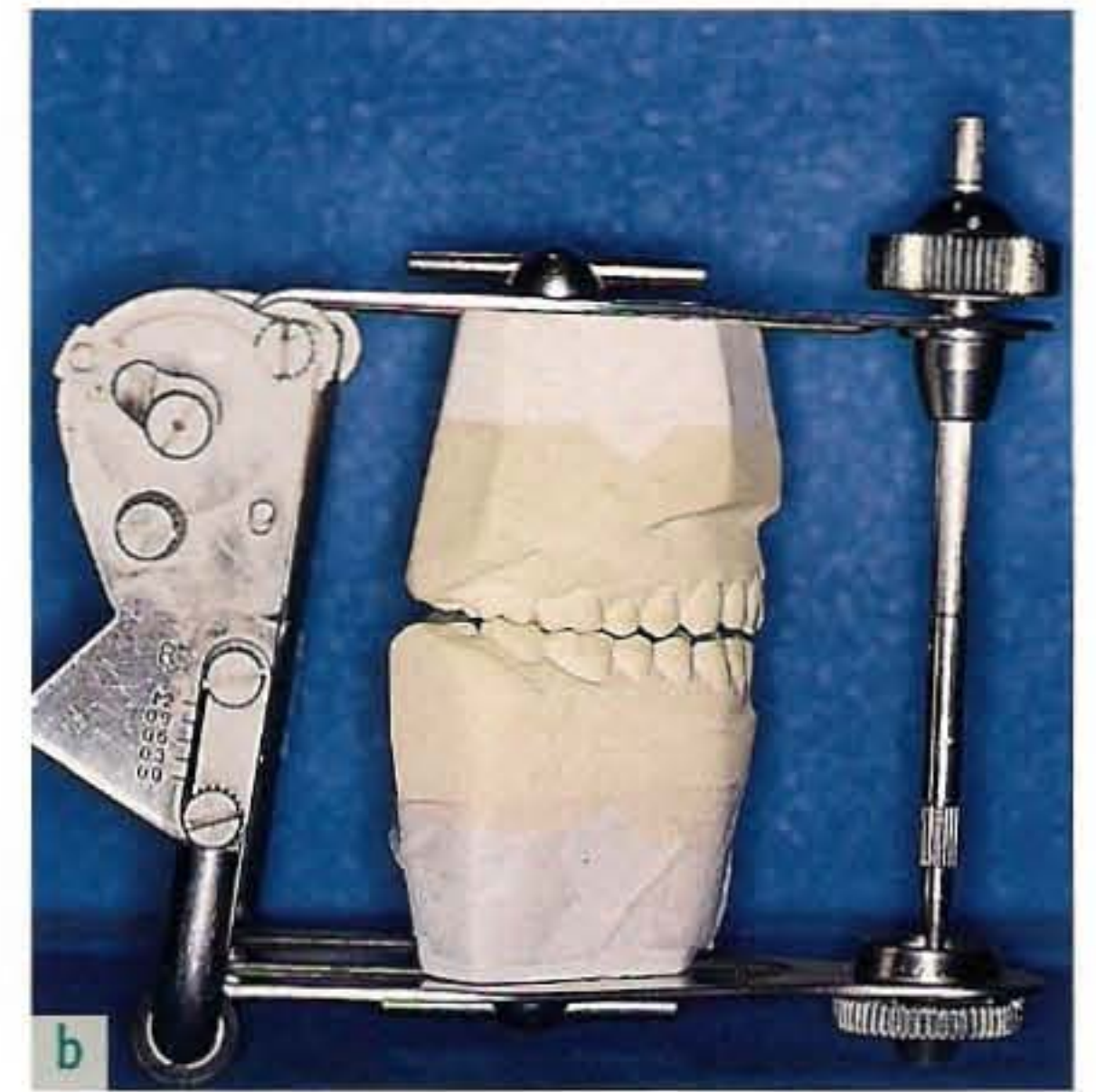
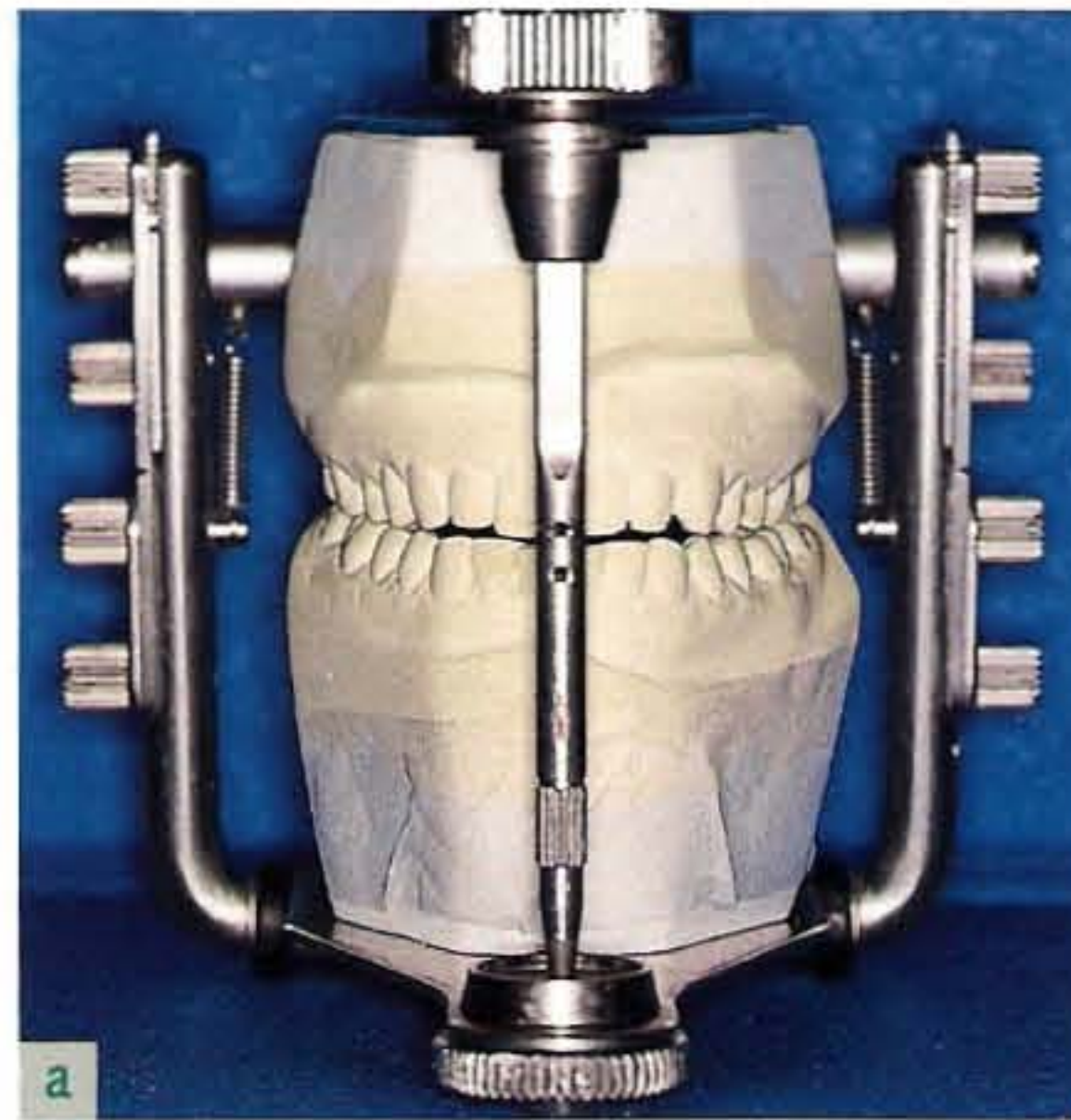


Fig 4-29 (a and b) Indirect occlusal analysis.

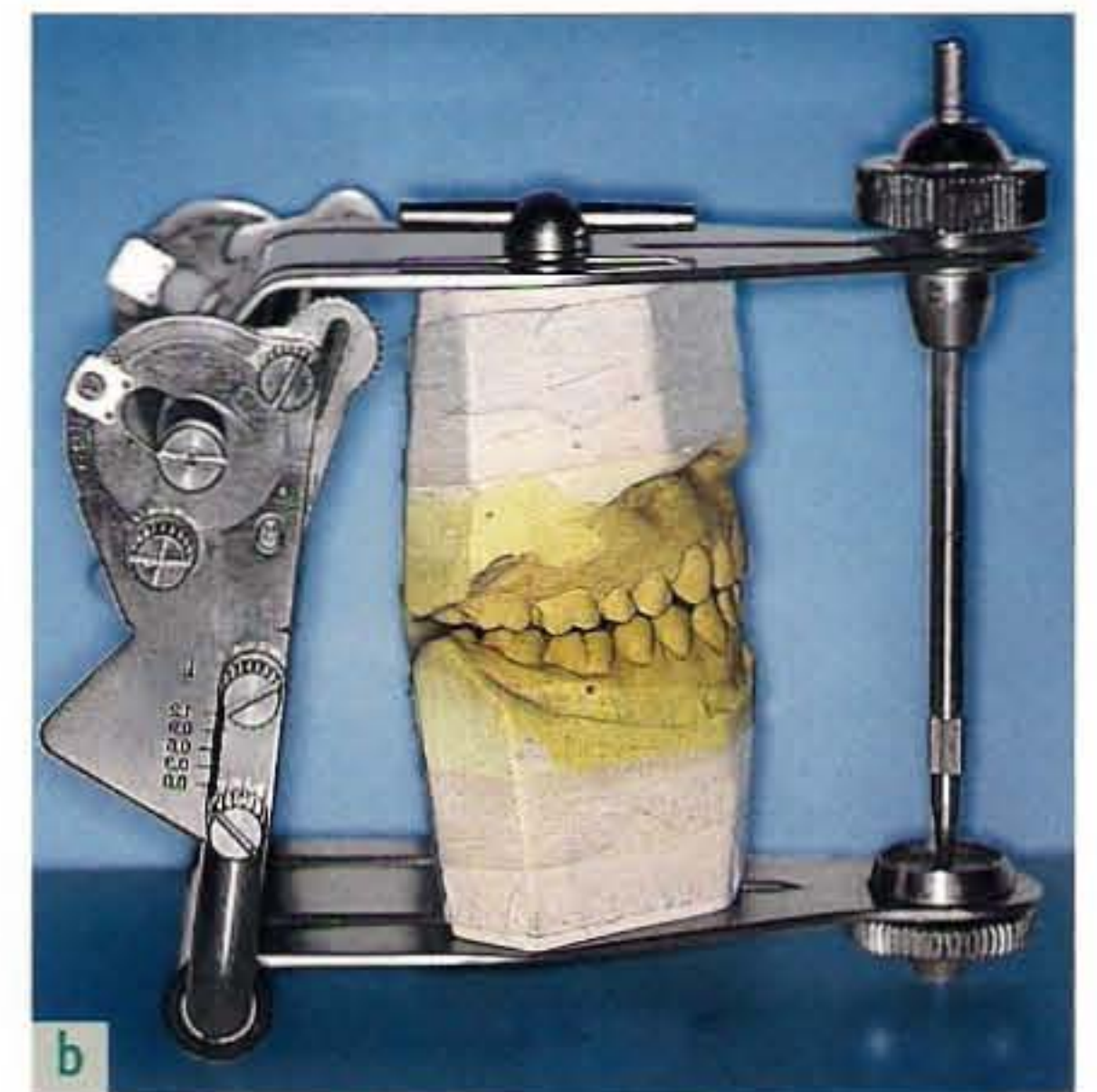


Fig 4-30 (a and b) The ring nut of the articulator is released.

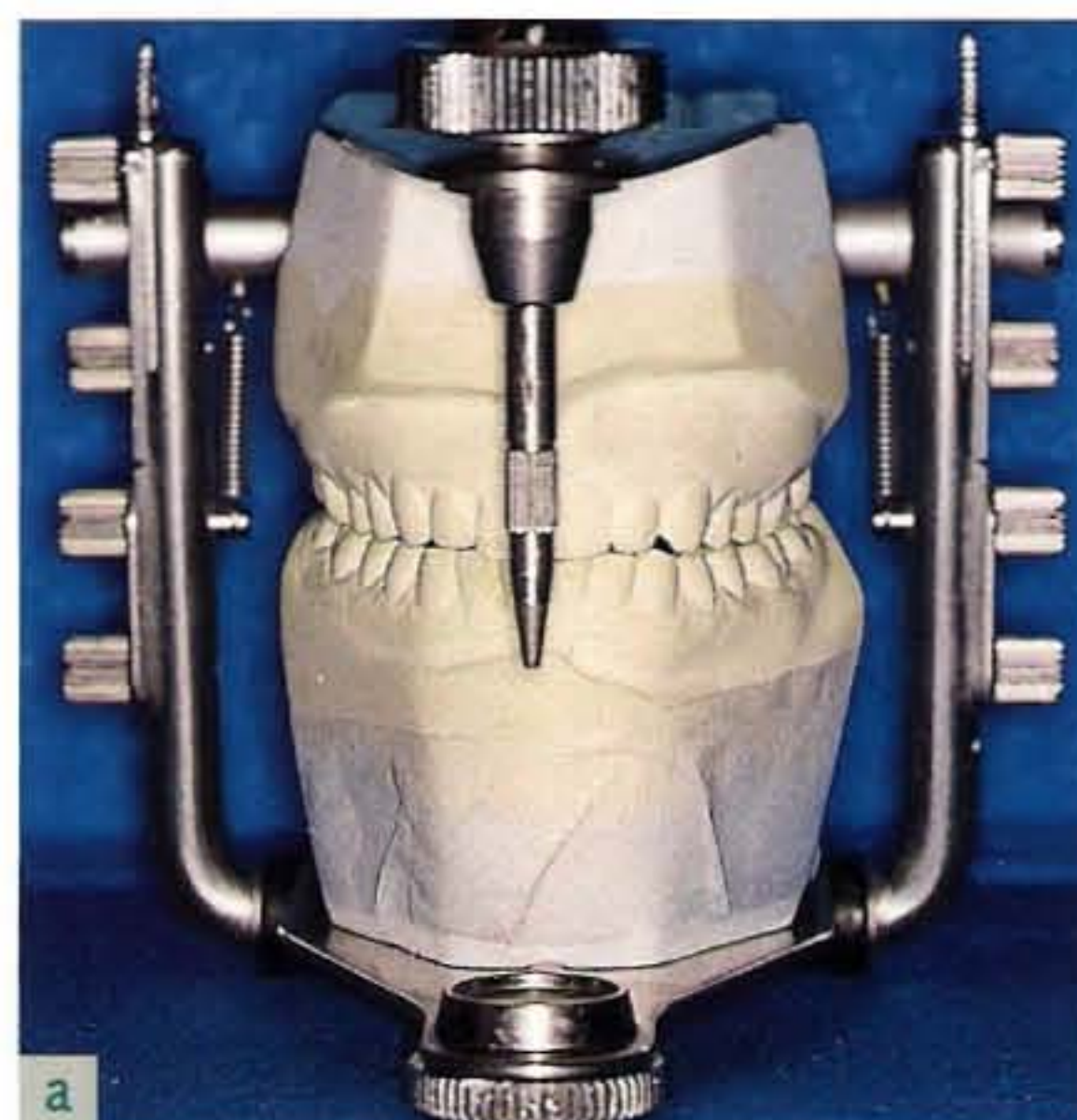


Fig 4-31 (a and b) With the rod raised, maximum intercuspation is found.

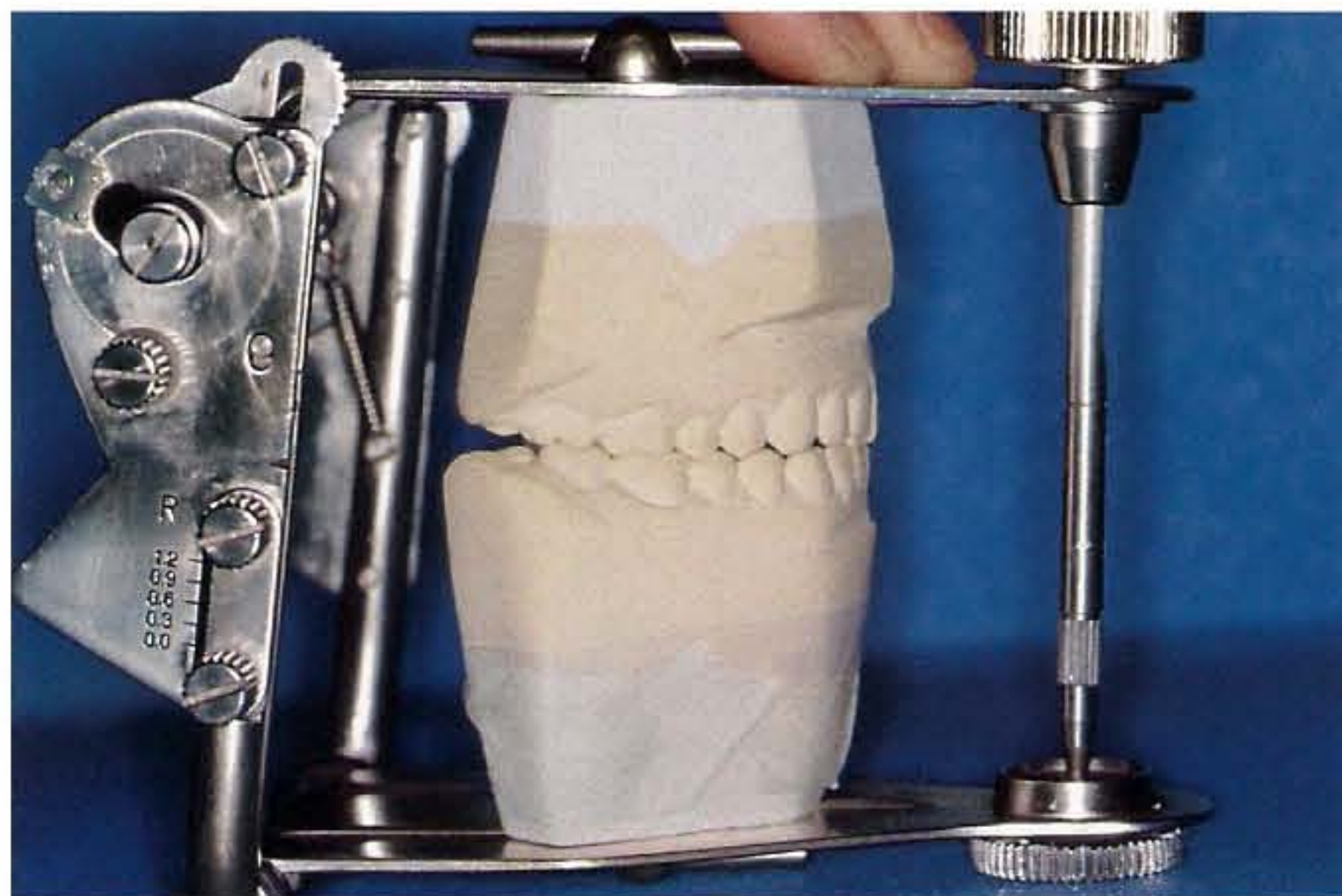


Fig 4-32 The rod is lowered to the VDO in maximum intercuspation.



Fig 4-33 Operative margin.

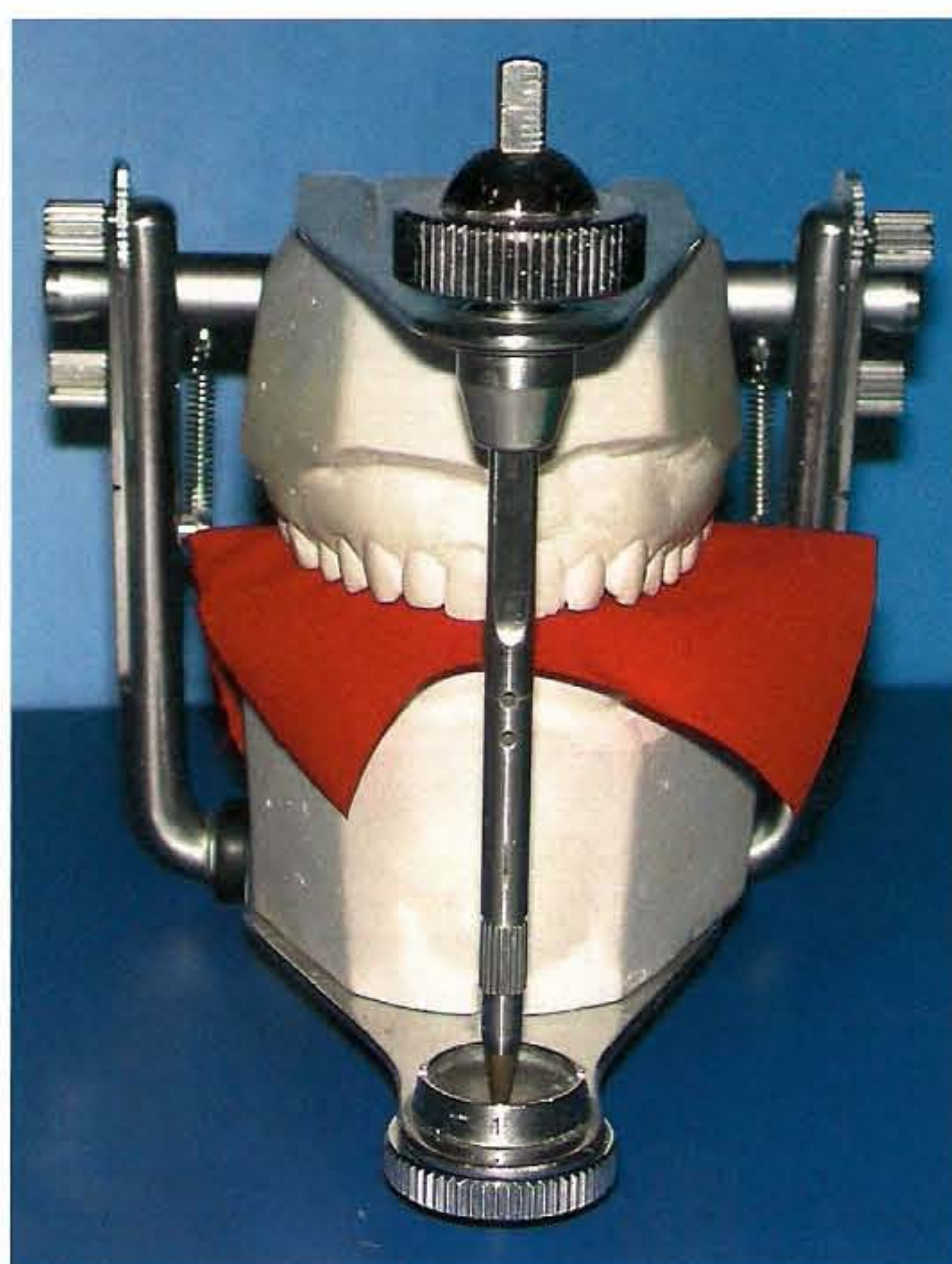


Fig 4-34 Red silk is placed between the casts and they are delicately placed in occlusion.

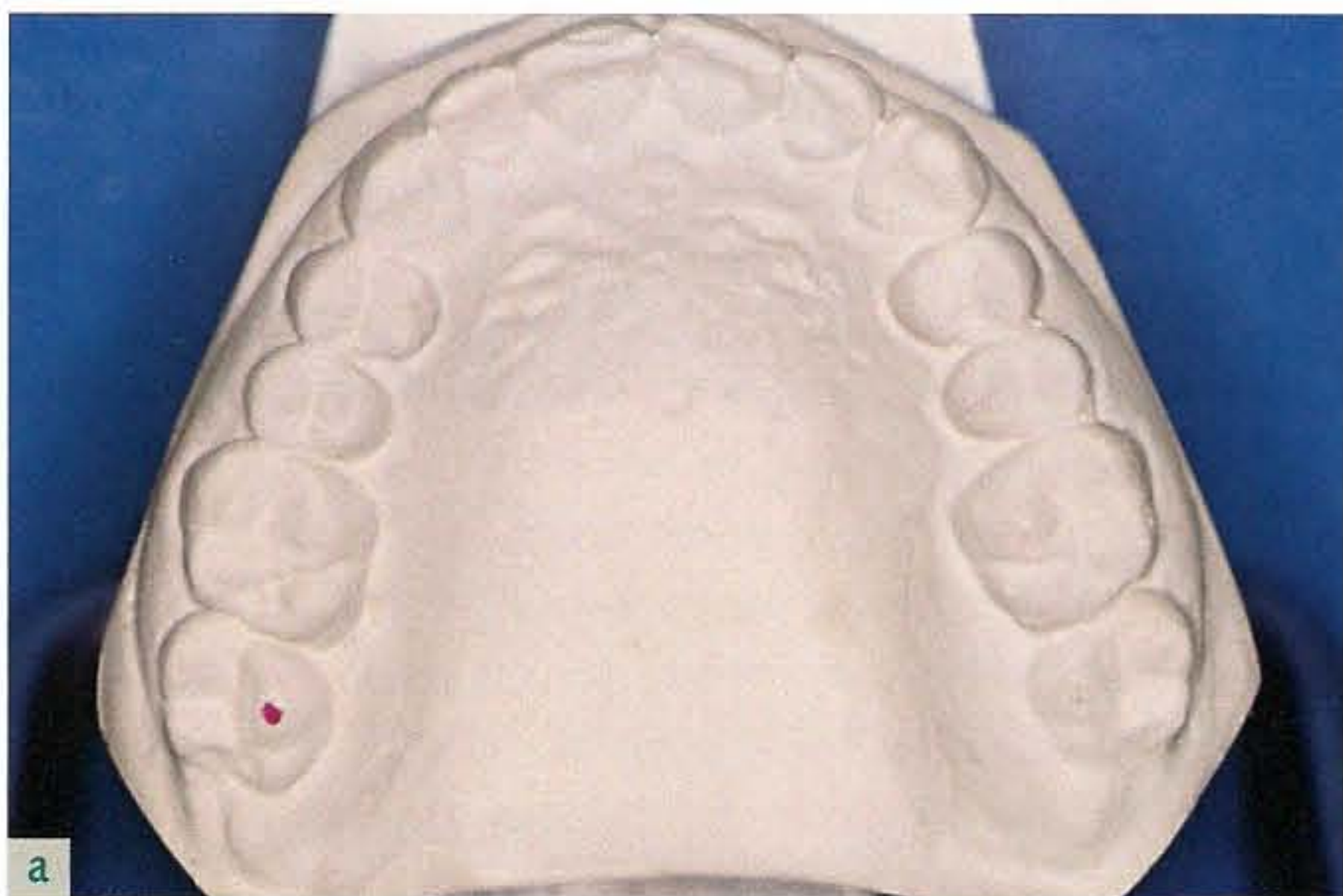


Fig 4-35 (a and b) The articulator is opened and the contacts are analyzed.

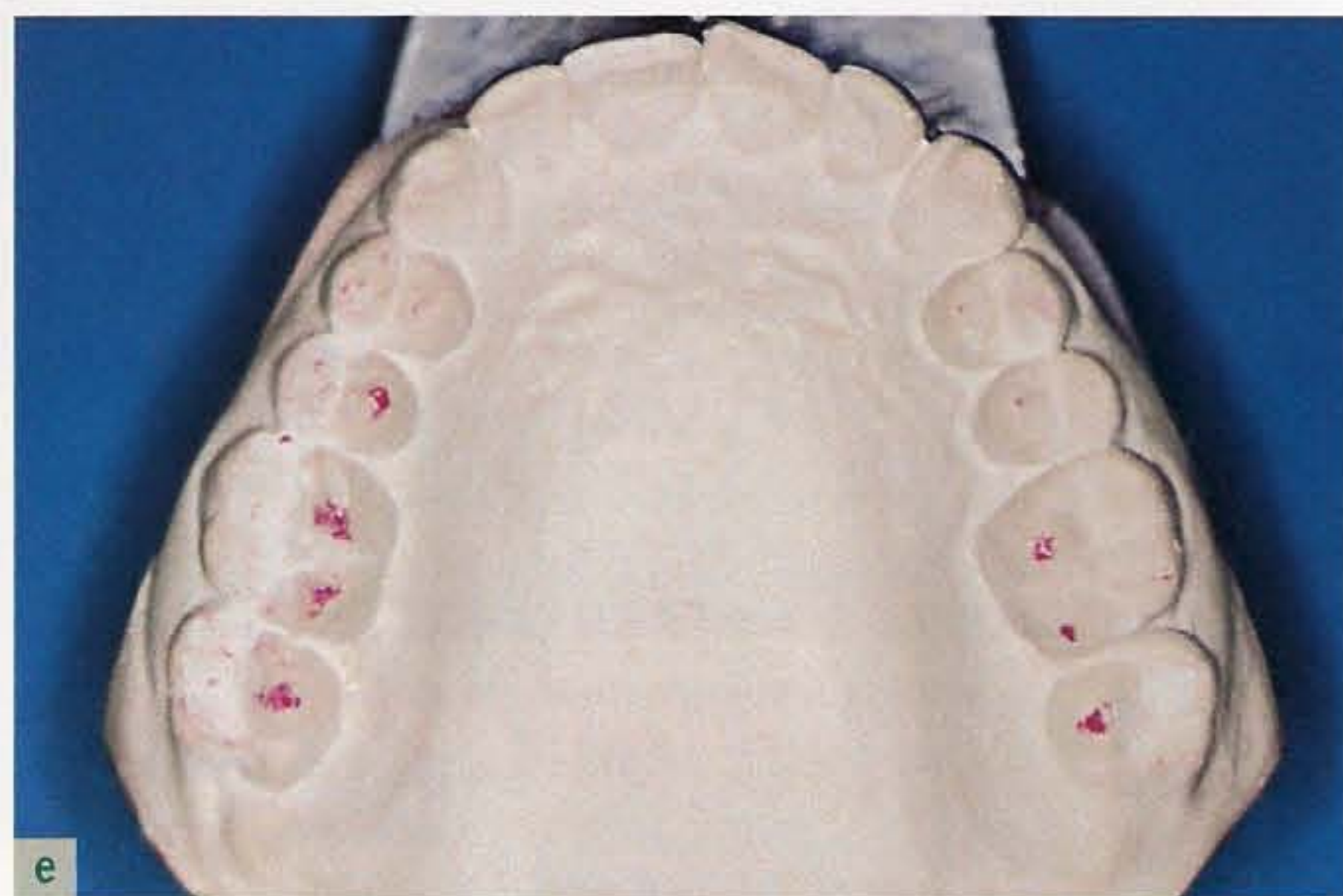
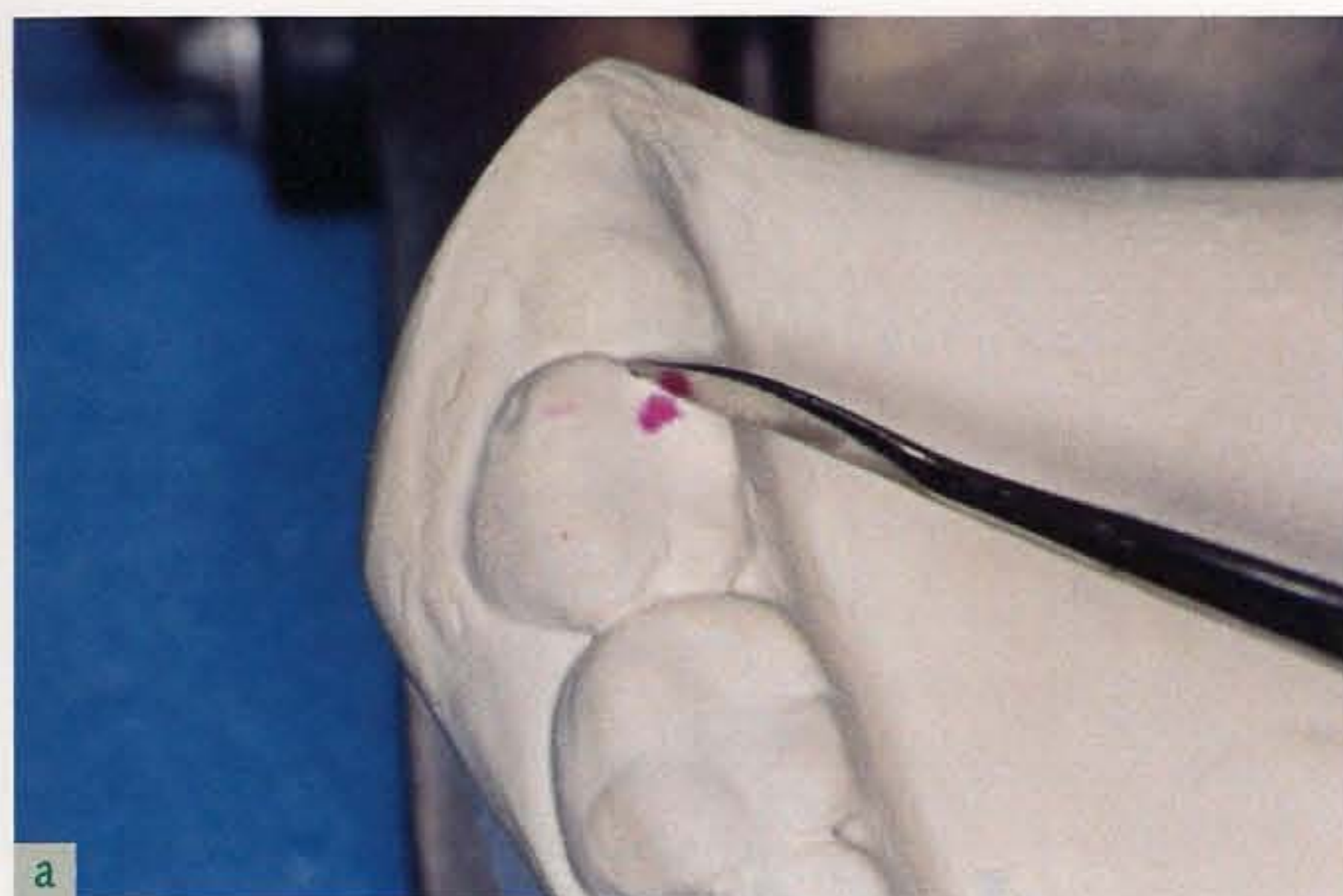


Fig 4-36 (a to f) Premature contacts are eliminated to reach a correct cusp-fossa relationship.

Operative sequence for selective grinding

Red silk is placed between the casts and they are delicately moved into occlusion (Fig 4-34). The articulator is opened and the contacts are analyzed (Fig 4-35). Premature contacts are

eliminated to arrive at a correct cusp-fossa relationship (Fig 4-36). Interference on the working side is eliminated, by grinding of only the noncentric contacts. Interference is eliminated on the nonworking side, by grinding of only the noncentric contacts.

Rules for selective grinding

- The maxillary palatal cusps must fit in the fossae of the mandibular teeth.
- The mandibular buccal cusps must articulate with the fossae of the maxillary teeth.
- Contacts must be present on both sides.
- Contacts must be present on canines, premolars, and molars.
- During movements, either canine guidance or group guidance must be present.

Summary

Occlusal therapy and prosthetic reconstruction cannot be carried out to prevent or cure TMDs. Occlusal therapy is only valid when significant changes in occlusion are needed for prosthetic reasons. Prosthetic treatment must only be executed after the reduction or remission of TMD symptoms, obtained through reversible therapy. Before definitive prosthetic treatment is performed, the VDO and the therapeutic position of the mandible must be established.

Maxillomandibular Relationships

Evaluations of the VDOs and of the maxillomandibular relationships on a horizontal plane are important, because it may be necessary to modify the relationship between the jaws and the occlusal levels for prosthetic rehabilitation (Box 4-9).

Maxillomandibular relationships in the vertical plane

Finding an adequate VDO for prosthetic use.

Unfortunately, research has not given a precise answer to establish which VDO is correct or when the VDO can be varied without danger of complications. Determination of the VDO is an empirical procedure based, above all, on clinical experience. There are methods based on individual evaluation: esthetic and phonetic methods, evaluation of physiologic rest position, evaluation of deglutition, and methods based on statistical data and preextraction data.

The VDO in the course of life is subject to continual variation. To reestablish maxillomandibular relationships in the vertical plane, it is necessary to satisfy the following clinical requirements:

Box 4-9 Definition of terms

- *Vertical dimension of the lower third of the face.* Defined as a measurement on the frontal plane between two arbitrarily located points, one above and the other below the oral opening. This definition refers to a vertical dimension of a "generic" face; it does not take into account the size of the opening of the mouth. It is necessary to take into consideration two specific vertical dimensions of the face.
- *Vertical dimension at rest (postural position).* Mandibular position determined at minimum muscular contraction.⁵⁷ This corresponds to the vertical dimension of the face with the mandible at rest and the masticatory and neck muscles in a state of relative rest. In this position, the muscles for raising and lowering the mandible show the minimum electromyographic activity (antigravity function). This situation is characterized by lack of interdental contact, and the lips are self-controlled. When forced closure of the lips is not possible in the rest position, there is labial incompetence, a lingual dysfunction, or an anterior open bite.
- *Vertical dimension of occlusion (VDO).* The distance measured between two arbitrarily located points, one above and one below the opening of the mouth, when opposing teeth are in contact.⁵⁷ This corresponds to the vertical dimension of the face with the arches in maximum intercuspation.
- *Interocclusal distance at rest.* The difference between the vertical dimension at rest and the VDO.⁵⁶ In other words, this represents the space between the occlusal surfaces of the maxillary arch and the mandible at rest.
- *Minimum phonetic space (or closest speaking space).* Among the numerous interocclusal functional distances indicated as the reference for the VDO,⁵⁷⁻⁶² the minimal phonetic space is agreed to be the distance between the incisal margins of the anterior teeth when the patient spontaneously pronounces words with an *s* consonant⁵⁷ (such as *sixty-six* or *Mississippi*).

- The presence of a free interocclusal space in postural position
- The absence of contact between the dental arches during phonation (closest speaking space)
- An esthetically pleasing appearance of the lower third of the face

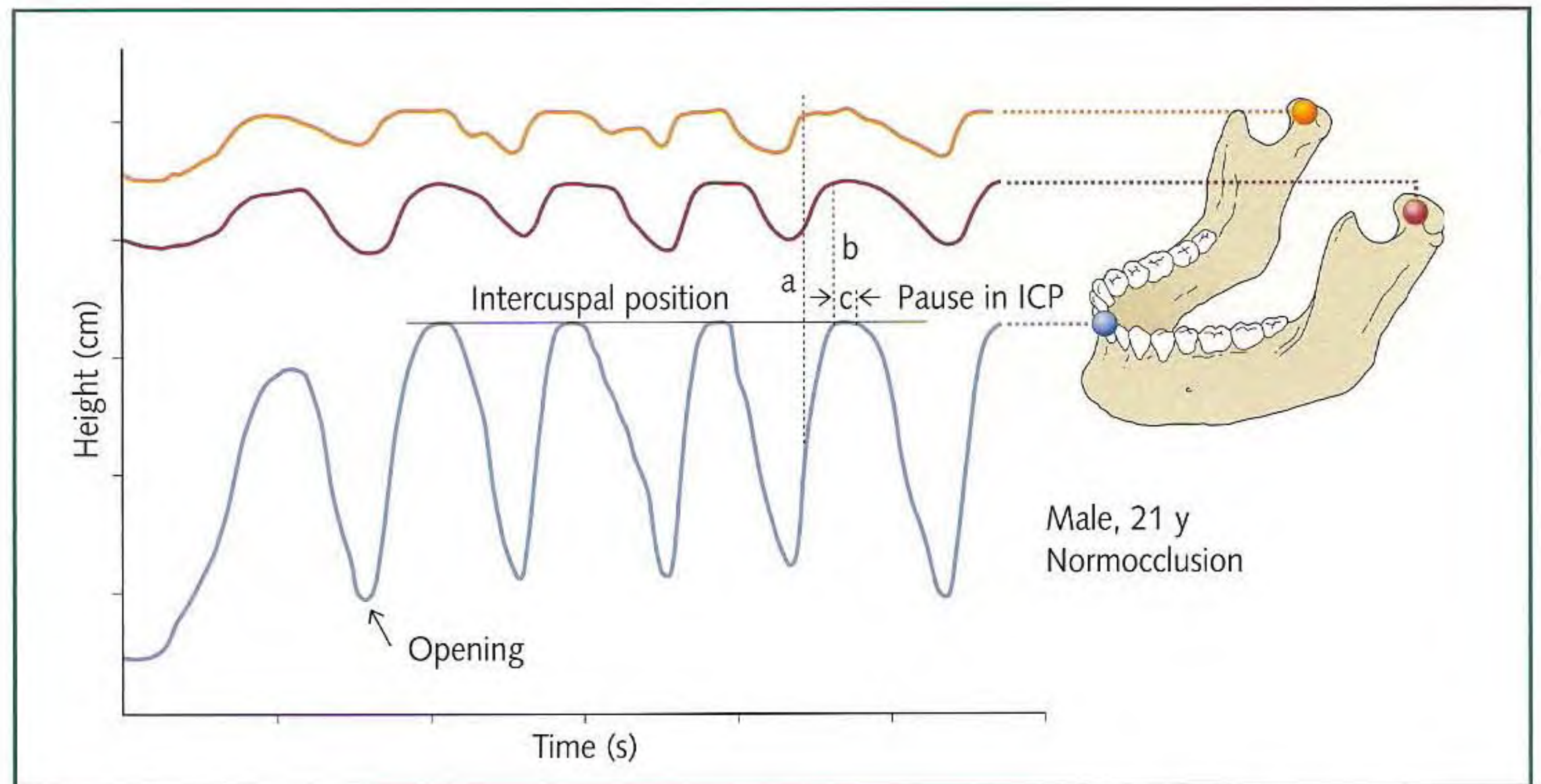


Fig 4-37 Movement on the vertical plane over time with a physiologic occlusion. The condyle of the working side reaches its highest position rapidly in closure (a) before any contacts between the teeth are evident. The condyle of the nonworking side reaches its final position at the same time as the teeth come into intercuspation (b). When maximum intercuspation is reached, the movement is arrested for 194 milliseconds (c). Hinge movement does not occur during mastication. (From Lundeen and Gibbs.⁶⁸ Reprinted with permission.)

Patients with an insufficient VDO

- The height of the lower third of the face is inadequate.
- The mandible protrudes.
- The cheek crease and the lips and chin are accentuated.
- The vermilion border of the lips is diminished.

Patients with an excessive VDO

- There is a sensation of being unable to close the mouth.
- Phonation, mastication, and deglutition are difficult.
- During phonation there are interocclusal contacts.

Patients with a correct VDO

- The cheek crease and the lip and chin area have a correct height.
- The vermilion border of the lip has a natural aspect.
- The sulcus of the philtrum appears natural.
- The height of the lower third of the face is in harmony with the rest of the face.
- Phonation, deglutition, and mastication are possible without difficulty.

Maxillomandibular relationships in the horizontal plane

In the past, the maxillomandibular relationship on the horizontal plane was transferred in the articulator, positioning the condyle as much as possible in the dorsocranial direction (ter-

minal hinge axis) for motives of reproducibility.⁶³ Successively in the 1970s, a geometrically centered position of the condyle in the fossa (condyle at zenith)⁶⁴ was considered correct.

More recent research on a large number of healthy people has indicated that the positions of the condyle in the glenoid fossa are variable.^{65–67} From the static point of view, the position of the condyle depends on the form of the fossa, the inclination of the tubercle, the form of the condyle, the morphology and position of the disc, and other variables. The dimensions of the joint cavity and its components are extremely variable, both in the sagittal plane (anterior, cranial, and posterior) and in the transverse plane (medial, central, and lateral).

During mastication, the working condyle reaches the highest position in the glenoid fossa before the teeth enter into contact. This position is maintained by the ligaments and muscles and must coincide with the trajectory of the closing of the mandible. Therefore, this is a muscularly adapted position⁶⁸ (Fig 4-37).

The greatest number of dental contacts during functioning occur in ICP or position 2 in Posselt diagram (Fig 4-38). This knowledge has been derived from analysis, by numerous authors, of occlusal contacts during mastication.⁶⁹

In an oral cavity without problems of a functional nature, the reference position on the horizontal plane is the habitual occlusion or ICP. The reference position must permit undisturbed interdental contacts in an area of about 1.5 mm around it (freedom in centric relation).

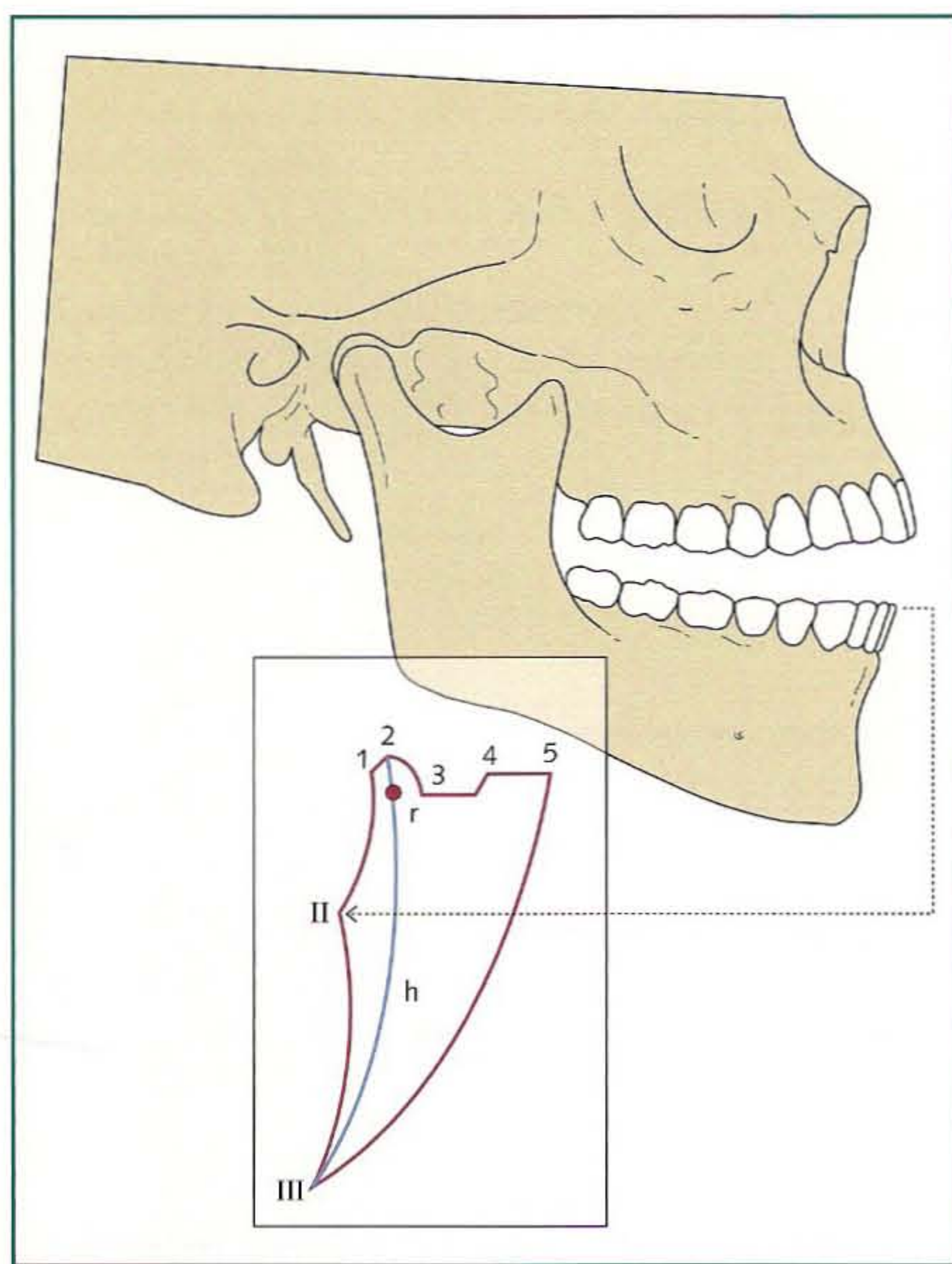


Fig 4-38 Posselt diagram: registration of the limiting opening-closing movements of the mandible in the sagittal plane, with the tracing point corresponding to the mandibular incisor: (point 1) Limiting position of contact at nonforced maximum retraction (in centric relationship or RCP); (trace 1-2) sliding in centric: passage of RCP to ICP; (point 2) centric occlusion, maximum intercuspation, or habitual occlusion; (trace 2-3) incisor guidance; (point 3) incisors in edge-to-edge position; (point 4) occlusal position in inversed incisal relationship with posterior tooth contacts; (point 5) limiting position of maximum mandibular protrusion with posterior tooth contacts; (point III) position of maximum opening; (point r) rest position; (trace 2-r) indicates freeway space or interocclusal rest space; (trace 1-II) movement of pure rotation of the condyles around the hinge axis; (trace II-III) movement of maximum opening; (trace III-5) movement of maximum opening in maximum protrusion with posterior tooth contacts; (trace h) habitual movement of opening and closing or the arc of closure with a postural rest position.

In consideration of these physiologic and anatomic data, now it is believed that there is not, a priori, a correct condyle position. Consequently, the reference position on the horizontal plane is determined using functional analysis.⁷⁰

Determining the maxillomandibular relationships (a three-dimensional problem)

The means of determining maxillomandibular relationships depends on the functional condition of the oral apparatus. The relationship used for prosthetic rehabilitation, in addition to the "standard" prosthetic requirements, must be obtained when the patient has no pain or functional disturbances and a manipulable mandible:

1. Presence of a sufficient number of opposing teeth; the VDO is adequate. A nonforced manual maneuver of the mandible is required (eg, Dawson maneuver). The maxillomandibular relationship is determined with a simple occlusal wax.

2. Lack of a sufficient number of opposing teeth; the VDO is inadequate. The restoration of a correct VDO is determined clinically. A dynamic or static facebow and occlusal wax are used.

To transfer a cast for which the maxillomandibular relationship has been determined in a vertical dimension different from that of the occlusion, or where it is necessary to vary the VDO, a facebow is used. The facebow permits orientation of casts on the articulator based on the intercondyle axis and the distance between the condyles. There are positional or static facebows, used for transferring the maxillary cast to the articulator, and dynamic facebows, used for transferring the mandibular cast and for registration of the sagittal trajectory of the condyle.

Only the coincidence of the anatomic hinge with the mechanical hinge permits the registration of maxillomandibular relationships in a vertical dimension that then can be successively varied, without premature contacts occurring in the intercuspation phase (Fig 4-39).

Summary

If the mandible cannot be manipulated, or if there are functional disturbances, the maxillomandibular relationship must be considered as temporary (therapeutic occlusion) and maintained using a provisional restoration. The provisional restoration is then progressively modified with the improvement of the functional conditions. Maxillomandibular relationships can be considered definitive and the therapy completed only if muscular disease is absent and the mandible can be manipulated.

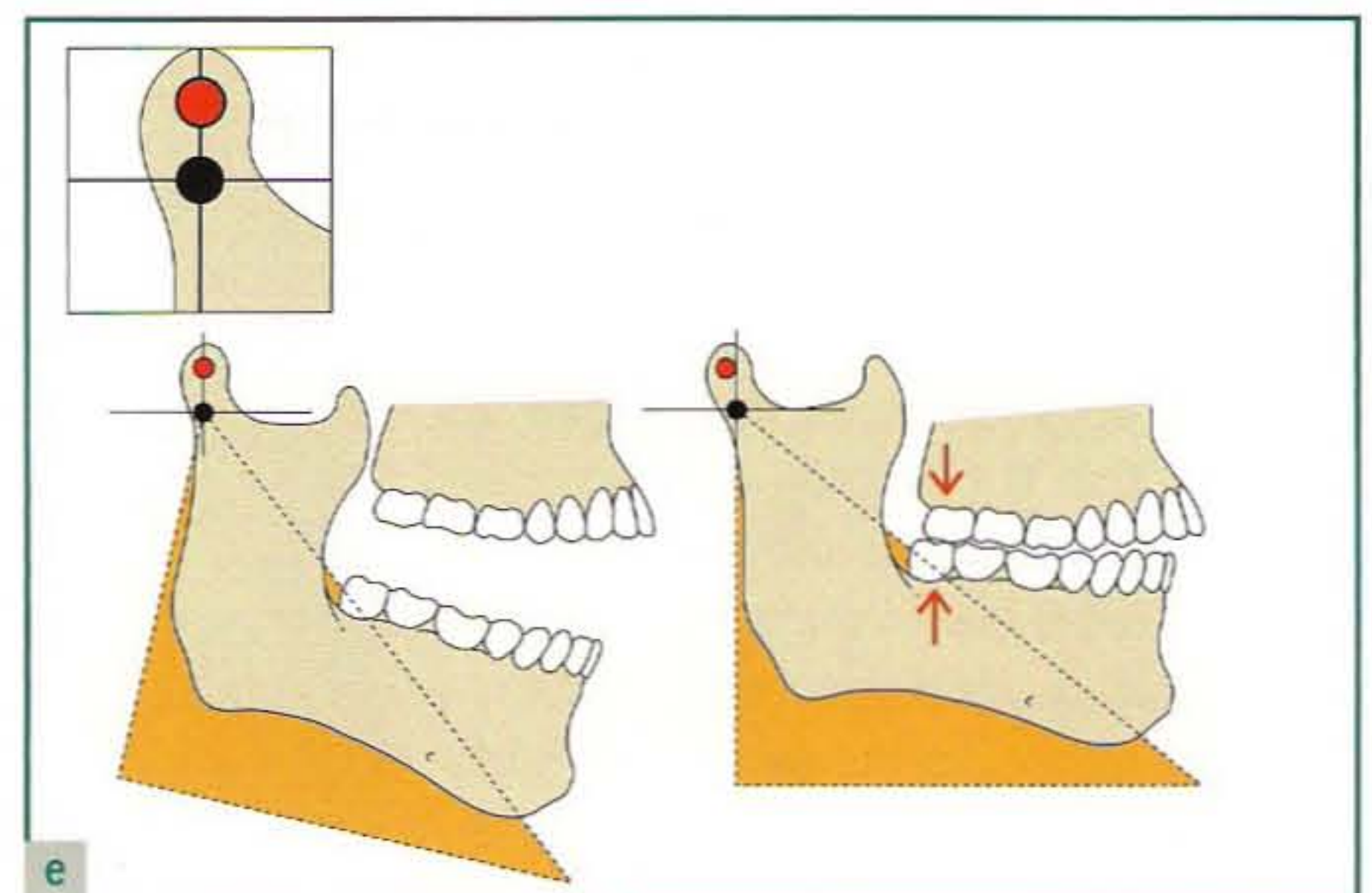
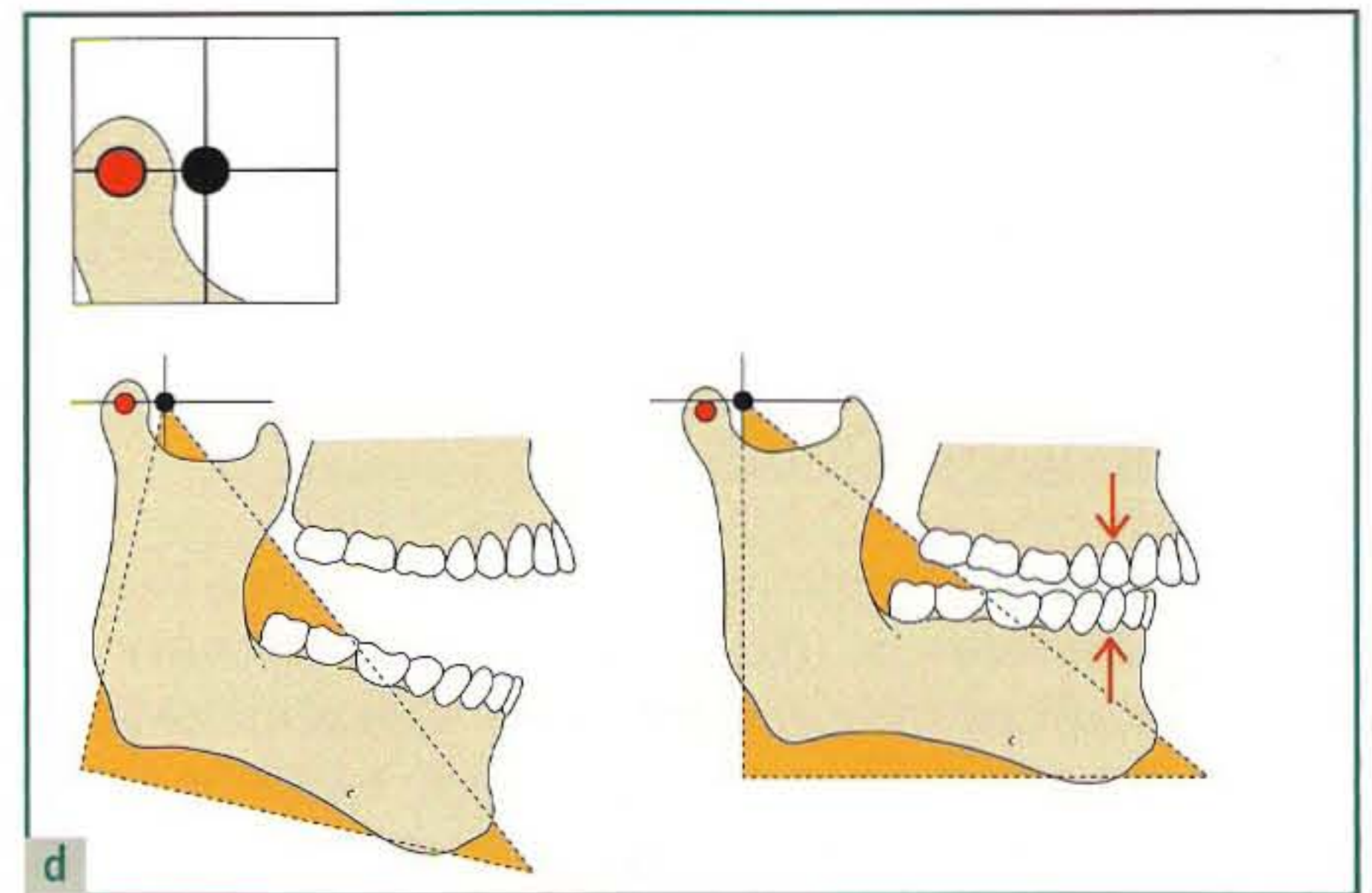
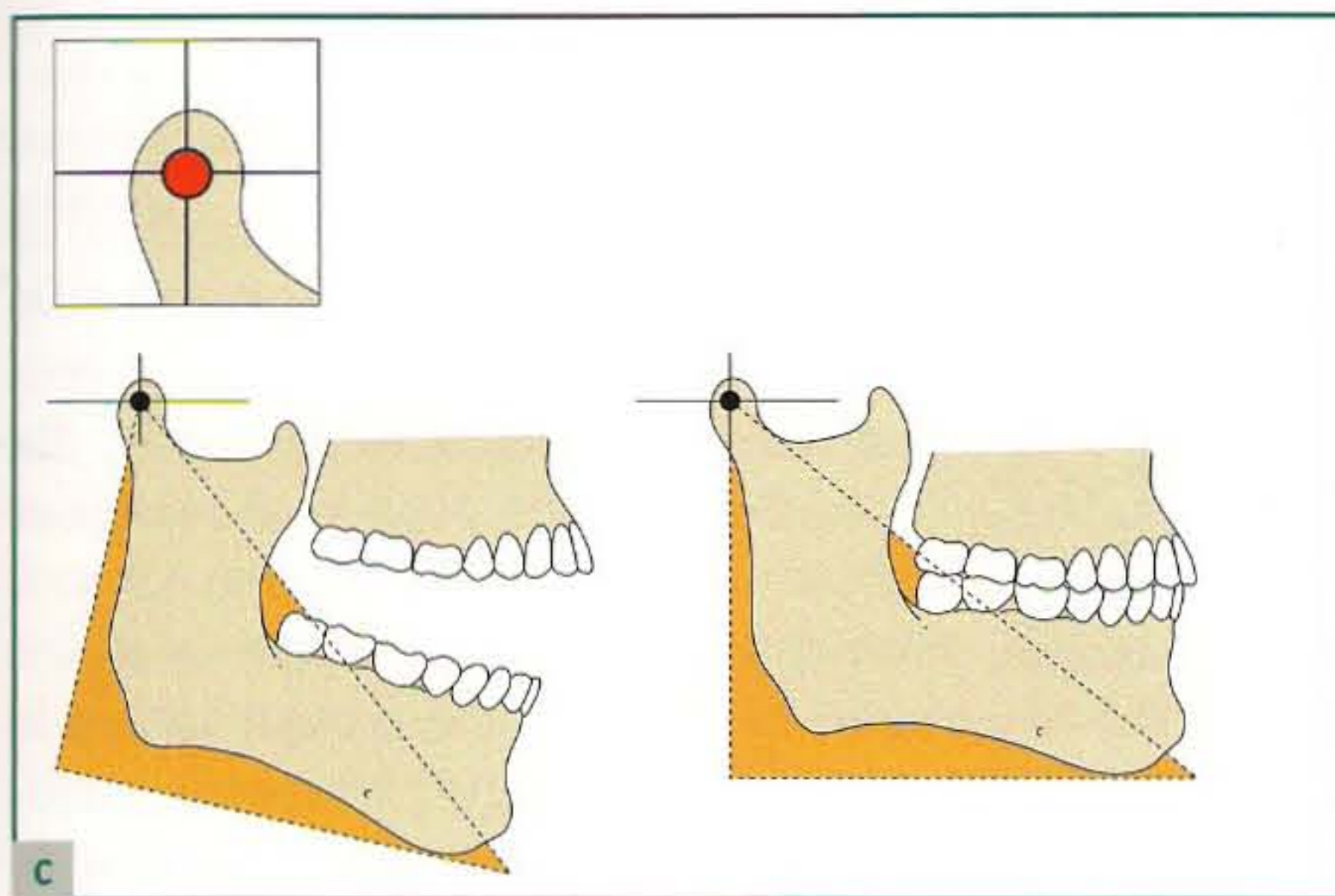
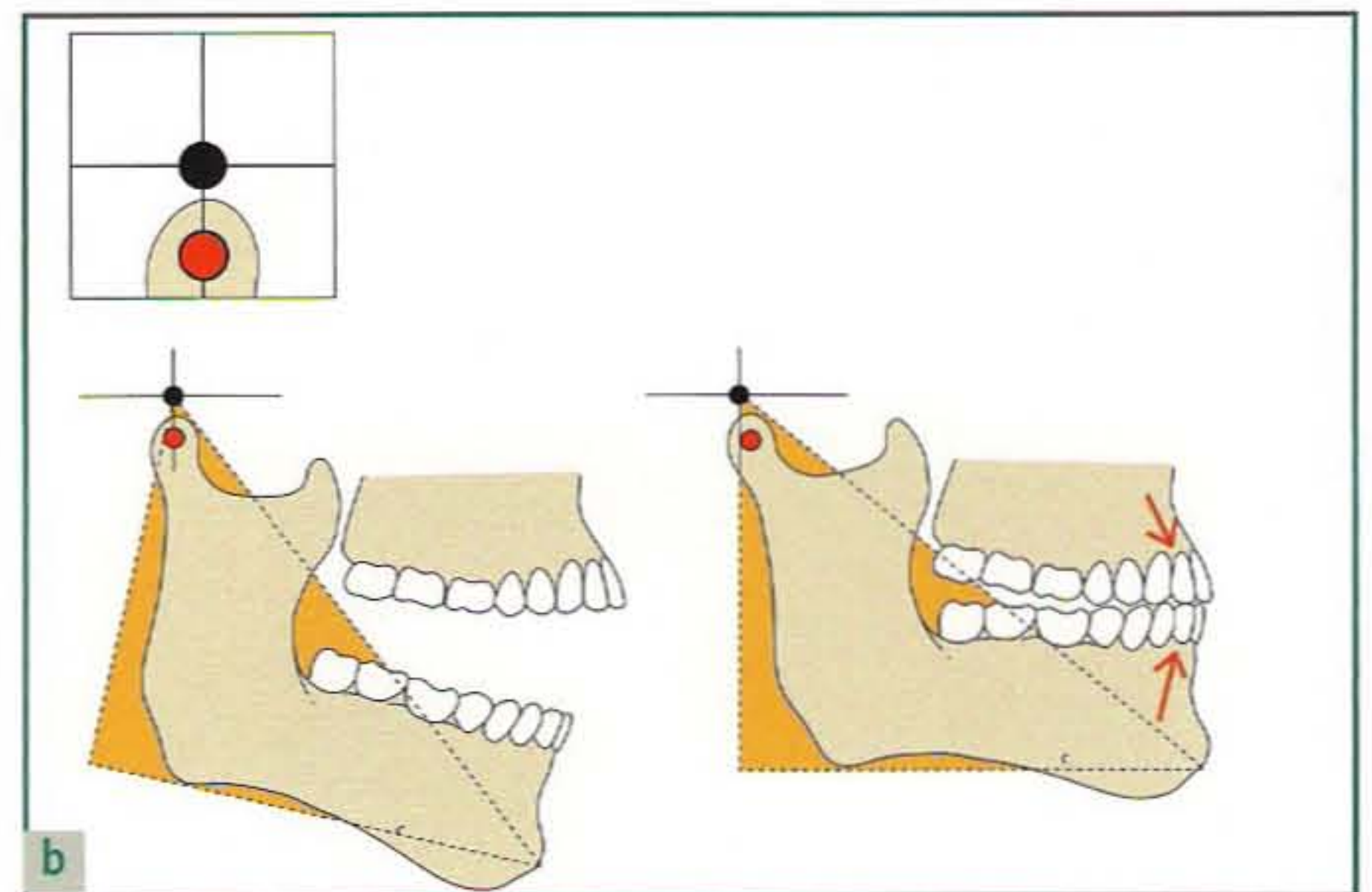
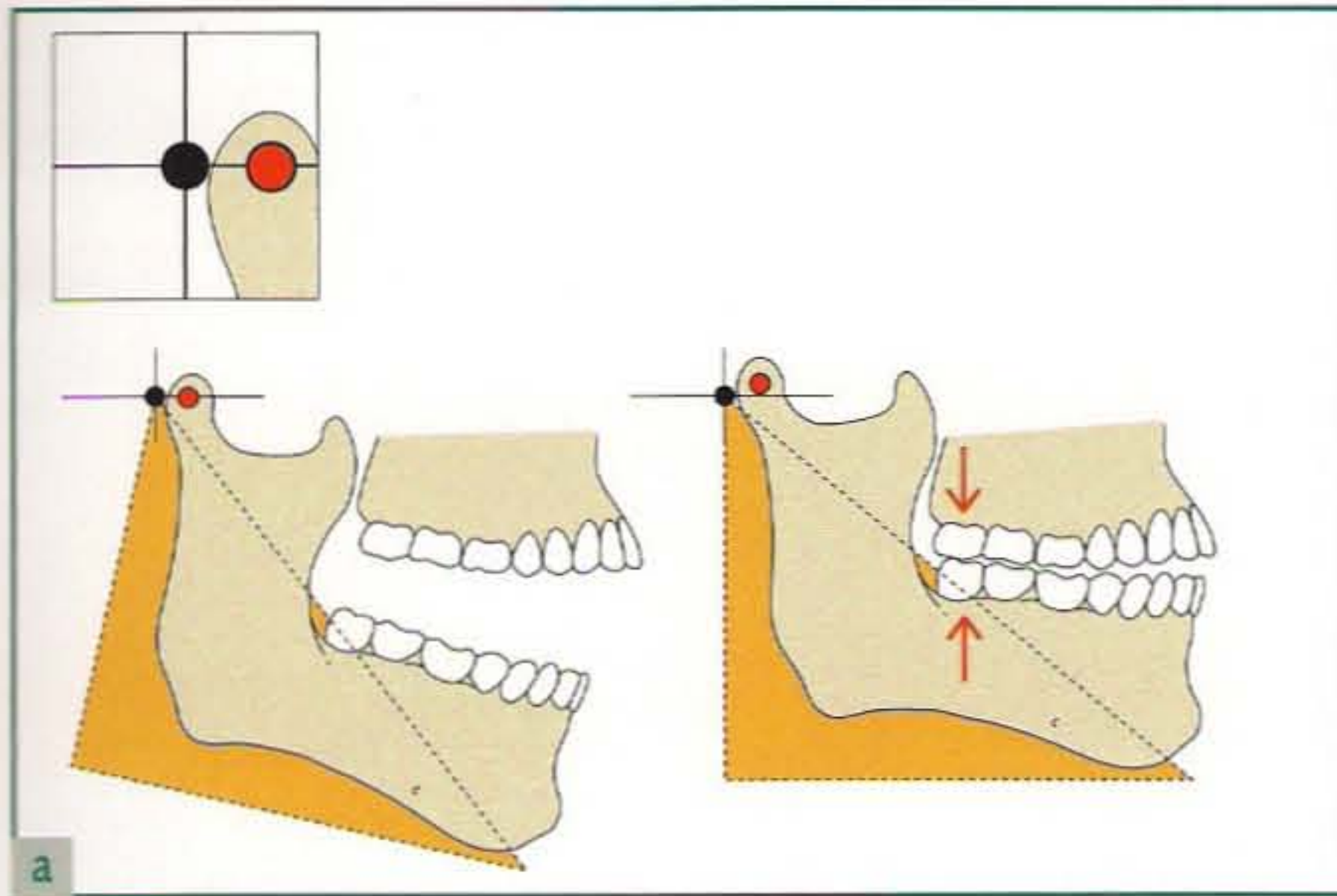


Fig 4-39 (a to e) Why use a facebow? A disparity between the axis of rotation of the mandible and that of the articulator (if the centric occlusion is raised to an increased vertical dimension) causes errors exemplified in the various diagrams.



Fig 4-40 Comparison between the occlusal plane of a young person and that of an elderly person. (a) The cusps, the crests, the fossae, and the sulci so evident in the young jaw (b) are less evident in the elderly as a consequence of usage.

Occlusal Morphology and Simulation of Movements

Occlusal morphology

The objective of reconstructing occlusal morphology is to assist the oral structures to adapt to prosthetic rehabilitation. Illustrations of human anatomy detail the occlusal morphology, showing the esthetic nature of crests, cusps, fossae, and sulci, not modified by functional contacts (Fig 4-40). This natural morphology adapts to the manufactured prosthesis, but the process may introduce functional risk factors. In an optimal adaptation to the prosthesis, the mandibular dynamics must occur without premature contacts or interference.^{71,72}

The occlusal design most favorable to this process must take into account the functional interdental contacts of the natural dentition. Telemetric studies have indicated that the contacts of a natural dentition during mastication are not always in the same position but that the central occlusal position generally corresponds to centric relation or ICP⁷³ (Fig 4-41). Nevertheless, there is great variation in masticatory function, and initial occlusal contacts can occur at many points, sliding in all directions rather like the pestle in a mortar (Fig 4-42). During swallowing, the contacts remain more or less in the occlusal centric position^{69,73} (Fig 4-43).

Occlusal contacts can vary in number, position, and intensity during the day. The total area of contact in ICP can vary over 24 hours, from a minimum of 0.5 to a maximum of 2.0 cm².⁷⁴ Thus, interdental contacts occur in a functional area, situated mostly anterior to the centric relation position.⁷⁵⁻⁸⁰

On the basis of these experimental observations, it is preferable to construct an occlusal morphology that has adaptive potential for the oral system, that may have a structure that is

not necessarily observable in nature, and that can be defined as therapeutic occlusal morphology. Such a morphology will have the cuspal contact points in a functional area (freedom in centric relations, long and wide).⁸¹ According to this model, the occlusal surface will provide, from the position of maximum intercuspation, freedom of movement of about 0.5 to 1.0 mm.

In a complex rehabilitation, maximum freedom in centric relation can be obtained by modeling the occlusal surface in accordance with Gerber's condylar theory⁶⁴ for complete dentures. According to this theory, the cusps are considered as microcondyles that function as pestles and occlude in the opposing fossae, similar to a glenoidal microcavity (Fig 4-44). This model favors a fossa design that is wider and concave rather than convex, reducing to a minimum the possibility of interference and premature contacts during function (Fig 4-45).

In this simplified contact model, the stability of the dental elements is guaranteed by at least one centric contact that is able to oppose the passive eruptive force for each tooth; the contact must occur with the summit of the cusp on a flat surface opposite the opposing fossa. The action of the transseptal fibers that tend to push the teeth sideways is canceled by the mesiodistal contact point, while the muscles of the tongue and cheek stabilize the teeth in the buccolingual direction (Fig 4-46).

The esthetic result also can be satisfactory for fixed prosthetic rehabilitation, especially if the buccal cusps in the mandible occlude in the fossae of the maxilla rather than the palatal maxilla cusps in the fossae of the mandible⁸² (Fig 4-47). This occlusal morphology has a further advantage of not creating interference during eccentric movements (protrusion and laterotrusion).

The occlusal morphology is strongly influenced by the cuspal trajectory during lateral movements, and this is also less protec-

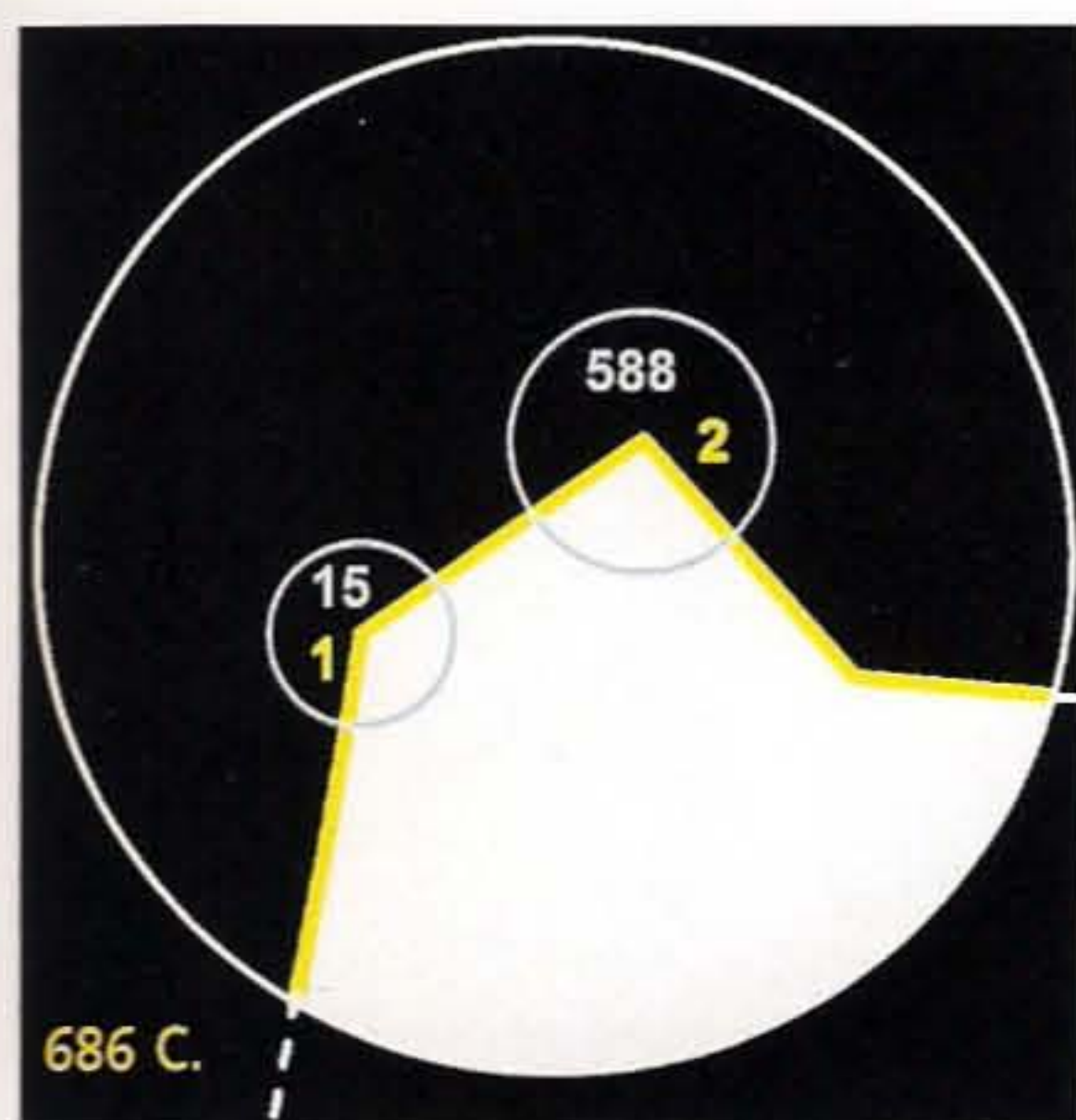


Fig 4-41 Contact during mastication, revealed by Pameijer et al⁶⁸ using telemetric registration. Of 686 contacts, 588 were registered in centric occlusion and 15 in centric relation.

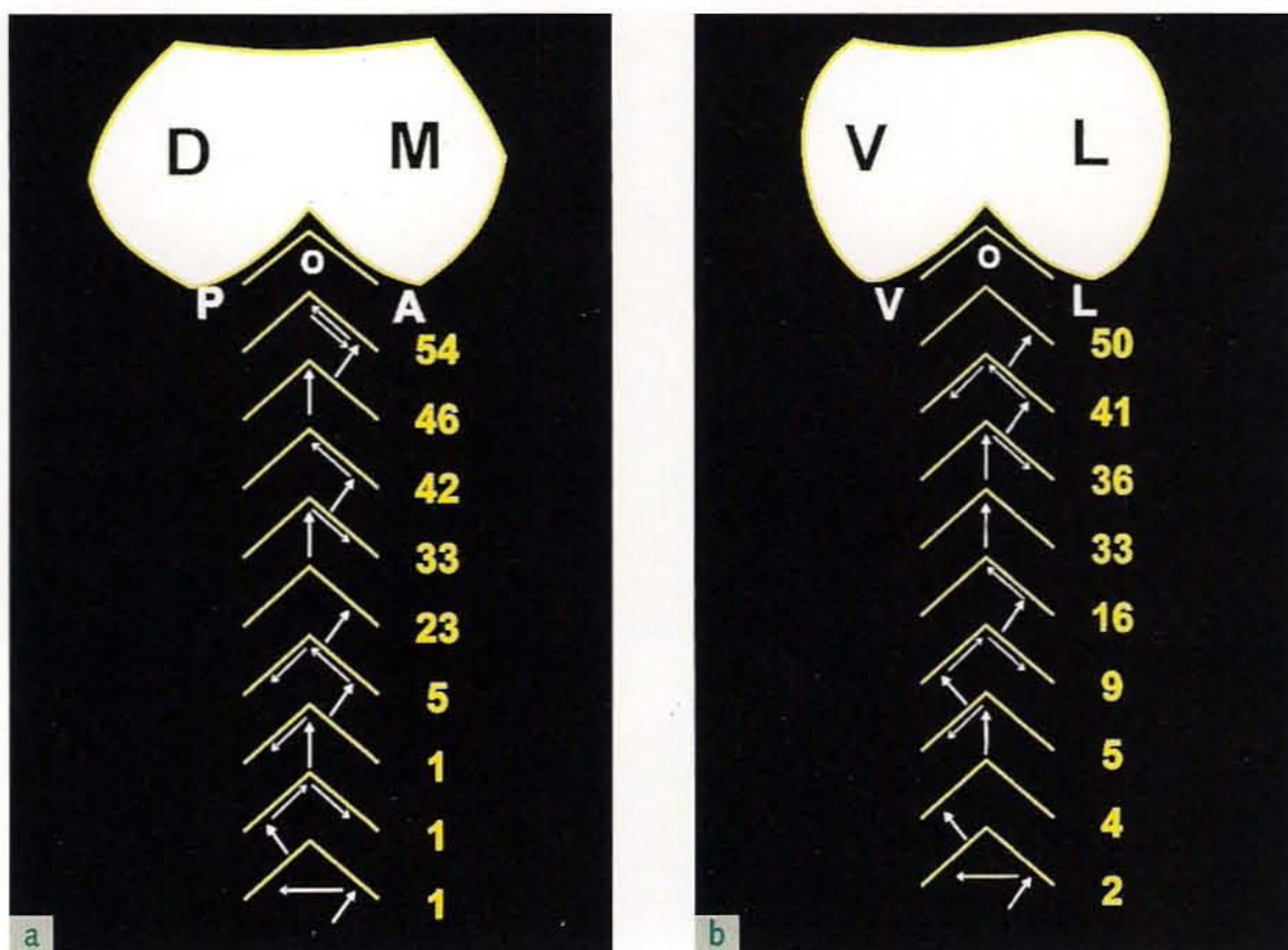


Fig 4-42 Different possible occlusal contacts or sliding observed by Pameijer et al⁶⁹ in a patient with a fixed prosthesis, equipped with a telemetric detector. The arrows indicate the localization and the chronology of the contacts. The numbers on the right of each type of contact indicate the number of contacts of this type that were registered. Note the numerous contact possibilities. (a) On the sagittal plane, the contacts were registered in centric occlusion (o), 0.75 mm in the posterior direction (P), and 0.75 mm in the anterior direction (A). (b) On the frontal plane, the contacts were registered in centric occlusion (o), 0.75 mm in the vestibular direction (V), and 0.75 mm in the lingual direction (L). (From Woda et al.⁷³ Reprinted with permission.)

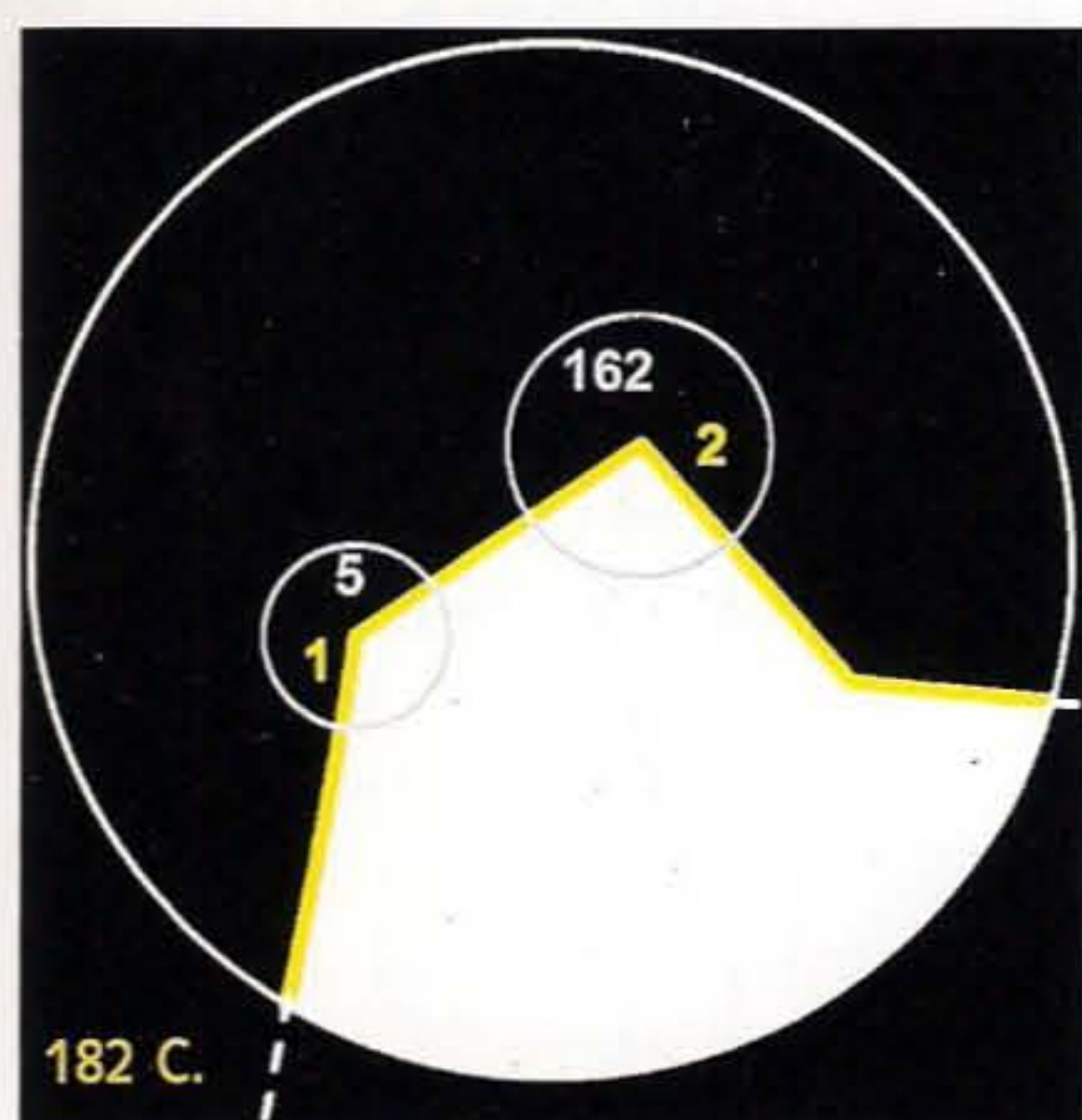


Fig 4-43 Contacts during swallowing revealed by Pameijer et al⁶⁹ using telemetric registration. Of 182 swallows registered, 162 had tooth contact in centric occlusion, 5 had contacts in centric relation, and the others showed contacts irregularly distributed on the horizontal plane around the position of centric occlusion.

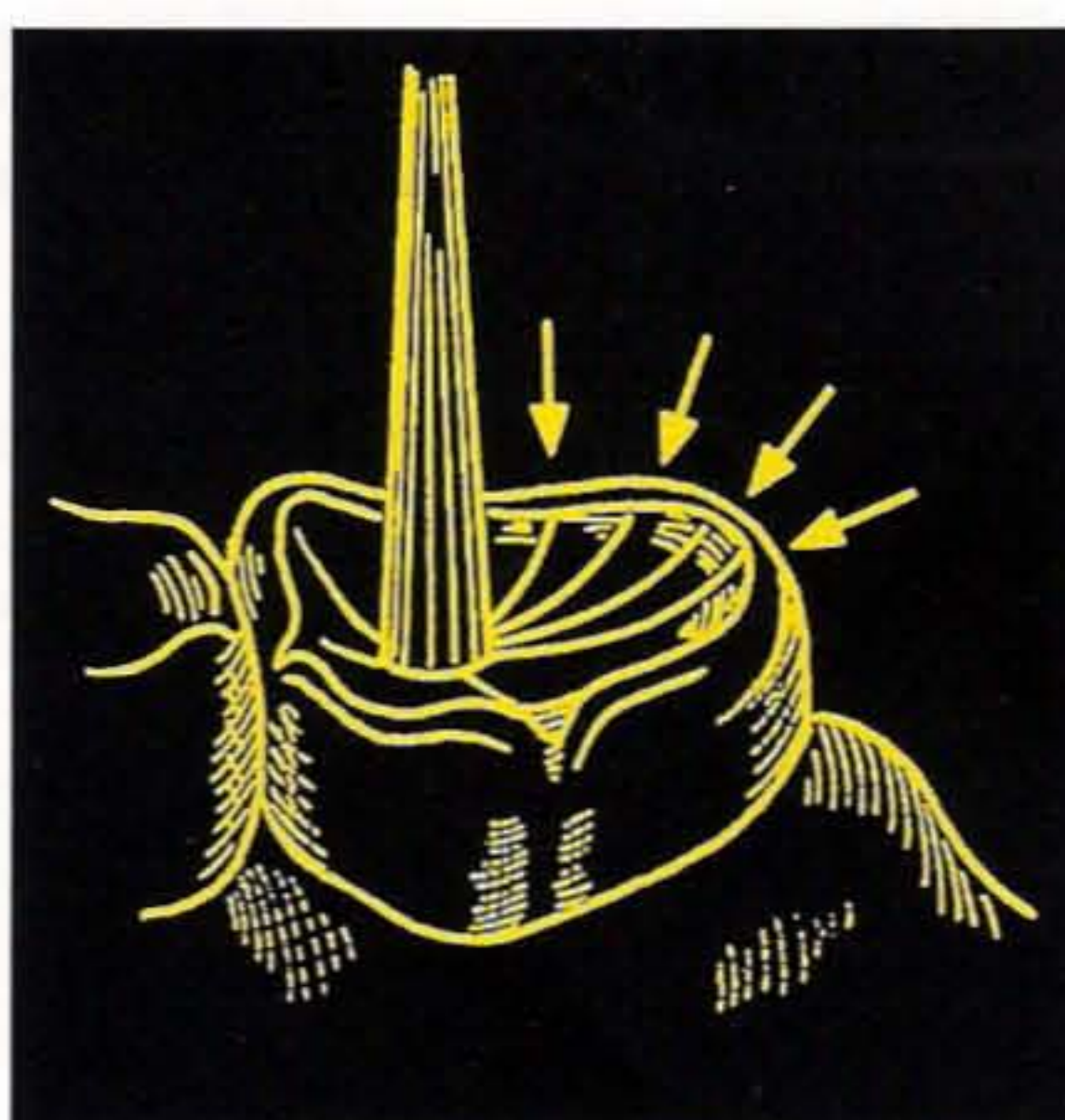
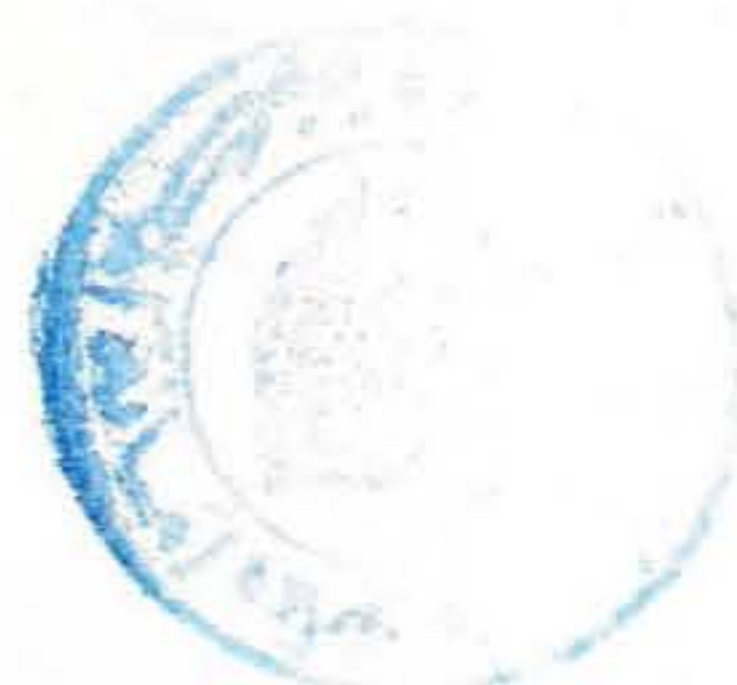


Fig 4-44 Maximum freedom of centric relation obtained by a pestle with small radius working in a mortar of a greater radius. This contact model designed for complete prostheses can also be adapted to restoration with fixed prostheses, especially in complex cases, where it is preferable to use an extremely functional morphology to the occasional detriment of esthetics. (From Preti and Pera.⁸⁵ Reprinted with permission.)



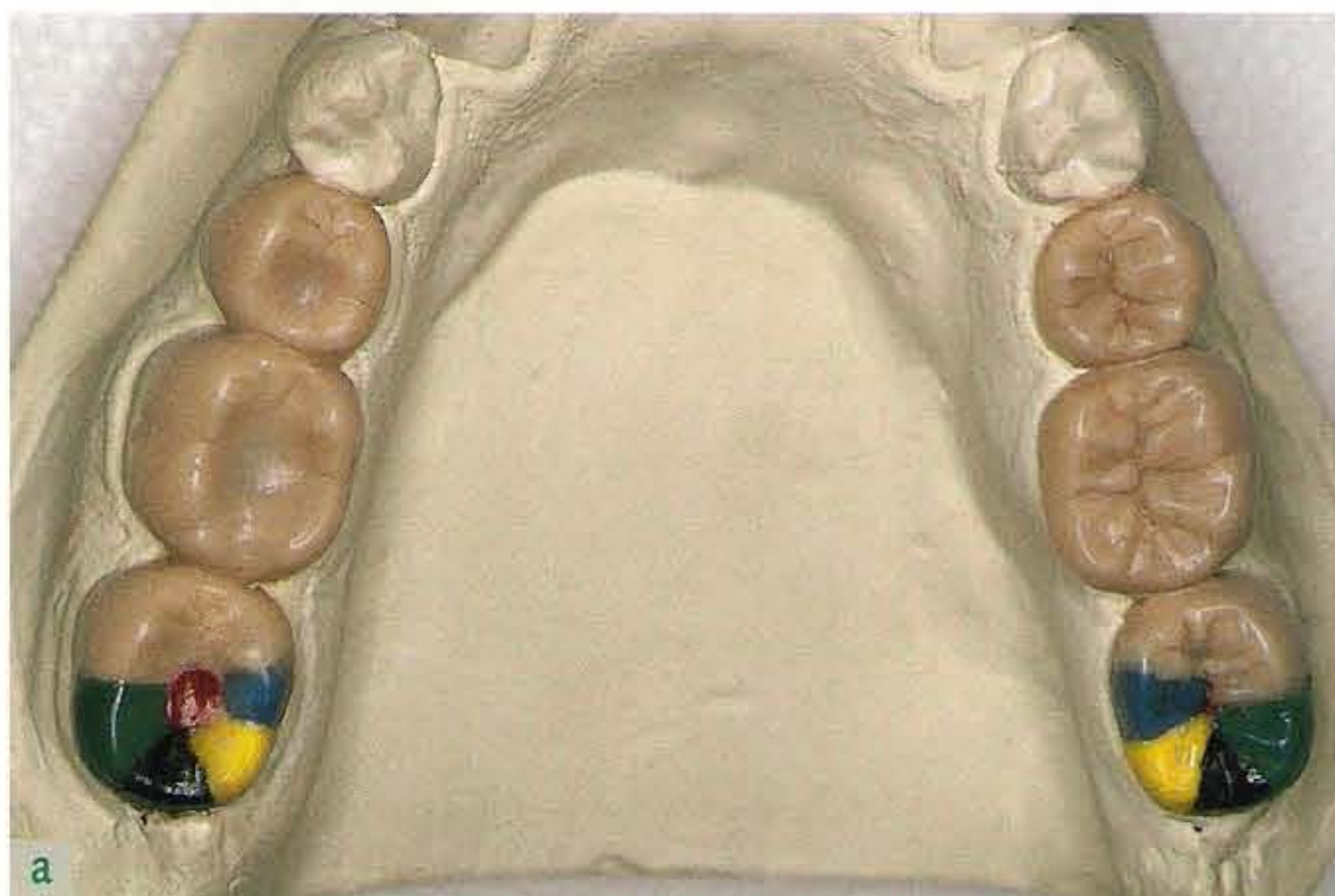


Fig 4-45 (a) Wax casts showing freedom in centric relation and gnathologic molds. Comparison of (b) freedom in centric relation with (c) the gnathologic molds reveals concave surfaces rather than convex, with the functional area of contact of 0.5 to 1.0 mm around the centric contact. (Prepared by Mr Gianmichele Viura, prosthetic laboratory technician.)

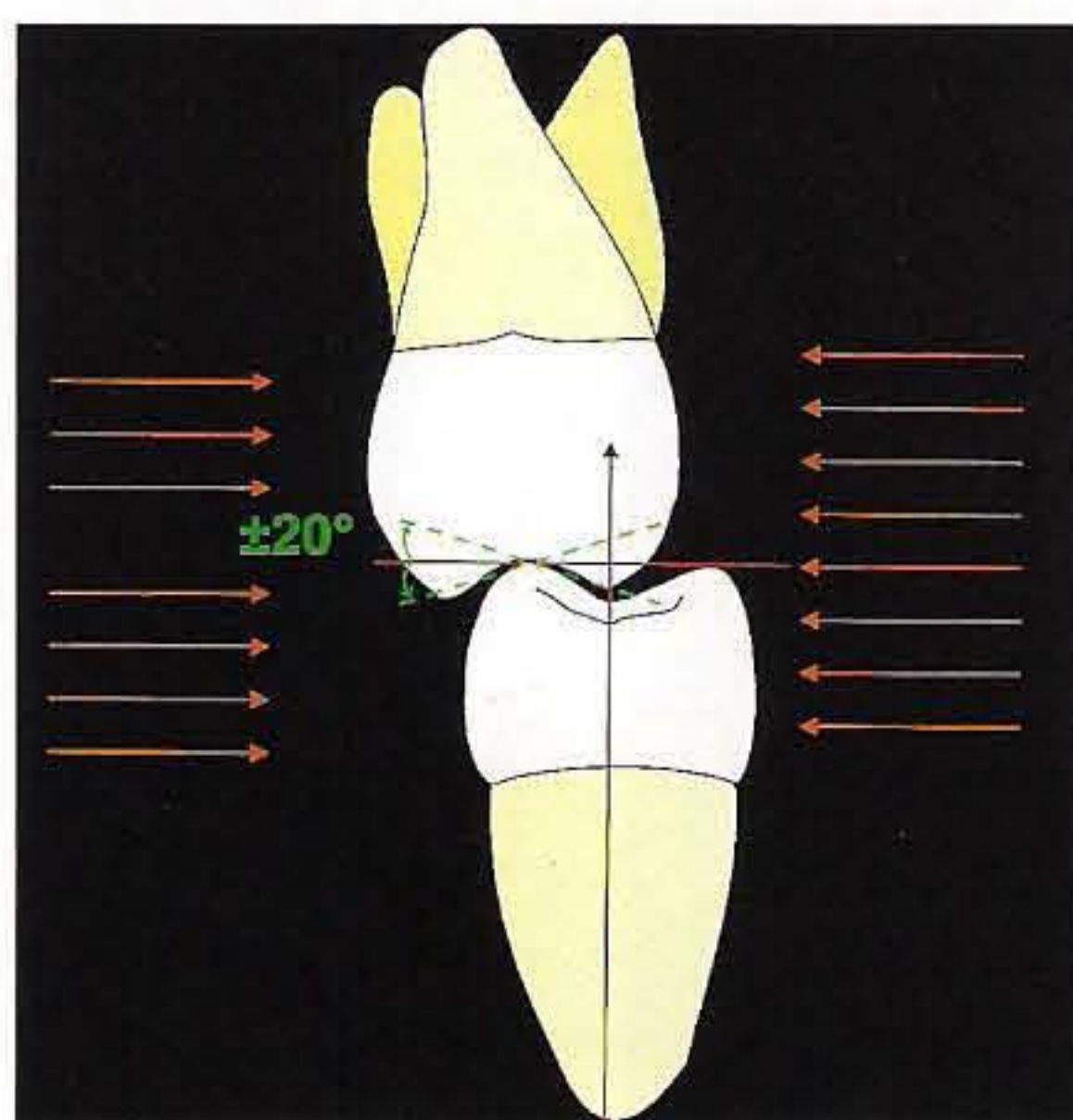


Fig 4-46 Forces that contribute to the stability of the teeth. The stability of the arch is sufficiently guaranteed by the presence of at least one occlusal contact per tooth and adequate interproximal contacts. (From Wiskott and Belser.⁸² Reprinted with permission.)

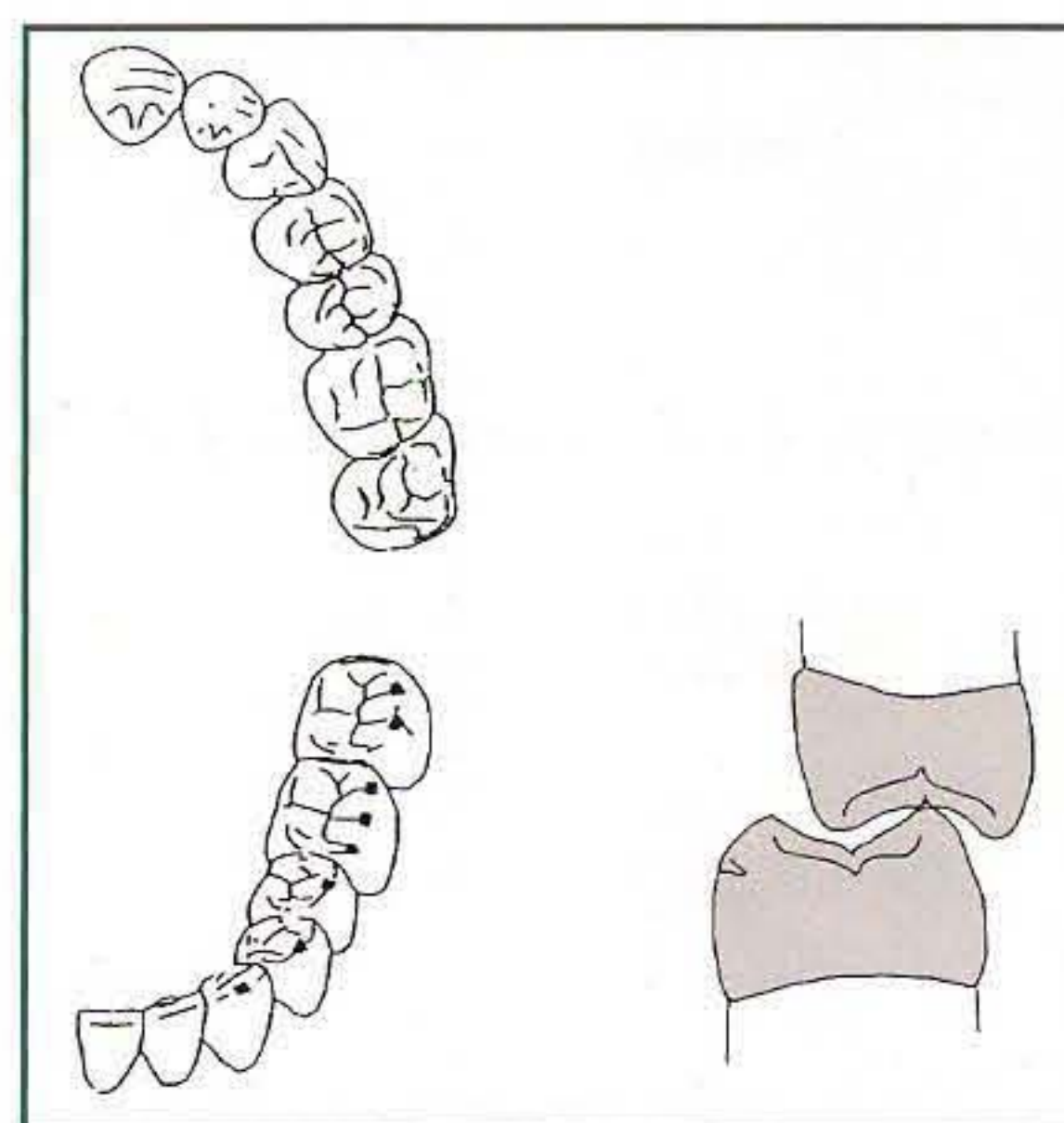


Fig 4-47 Simplified model of occlusal contacts. The number of contacts is reduced by 50%, and the contacts are between buccal cusps of the mandibular molars and premolars. (From Wiskott and Belser.⁸² Reprinted with permission.)

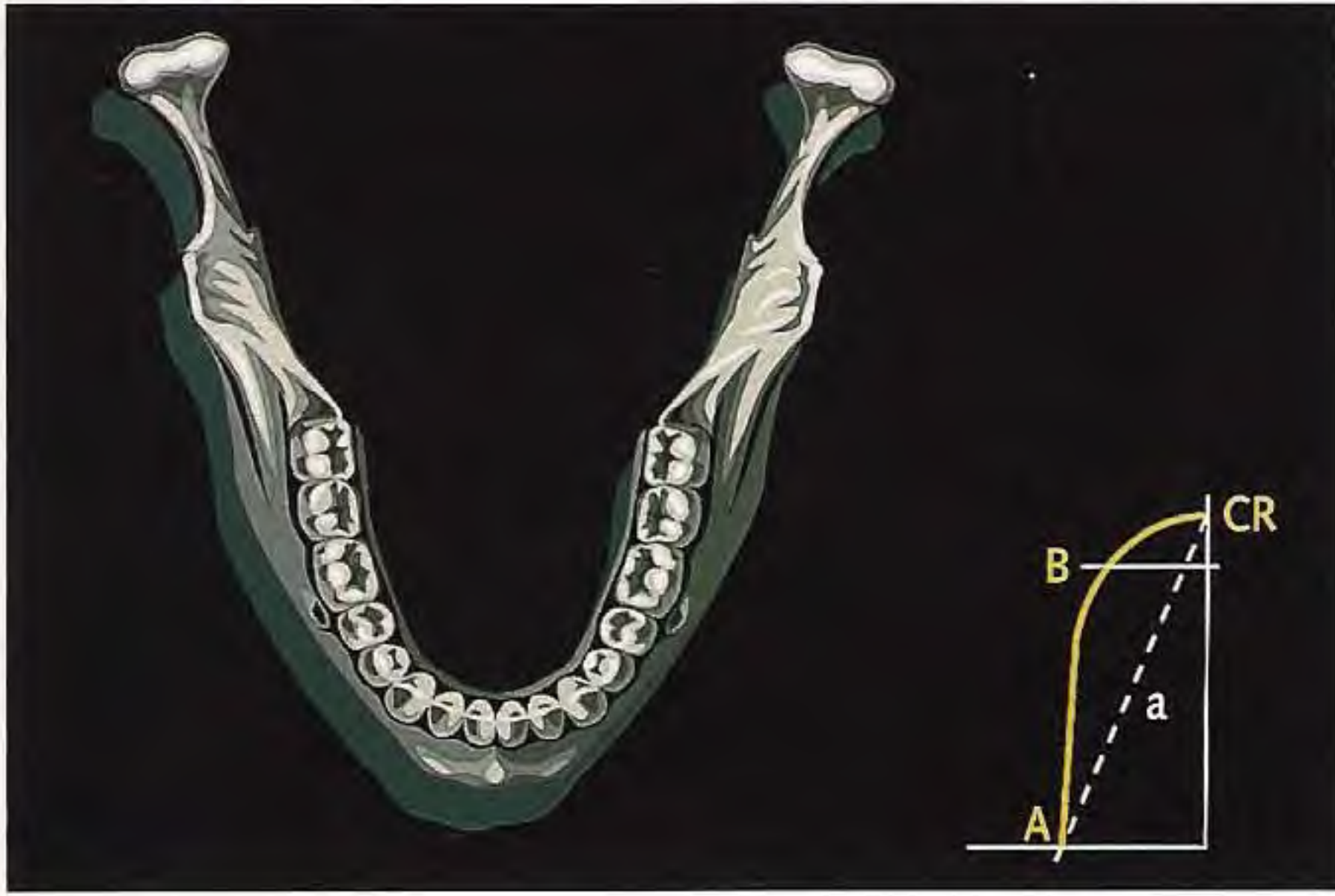


Fig 4-48 Immediate and progressive components of lateral movements registered on the horizontal plane. (CR) centric relation; (CR-B) immediate component of lateral movement; (B-A) progressive component of lateral movement; (a) Bennett angle. (From Preti and Pera.⁸⁵ Reprinted with permission.)

tive of the occlusion, giving immediate clearance for canines and groups of teeth on the working side (canine guidance and group function). In movements of laterotrusion, the stabilizing condyle moves forward, downward, and toward the interior. On the horizontal plane, in the majority of subjects, the movement is composed of an immediate component of a few millimeters in which the movement is exclusively lateral and a straight or progressive component (Fig 4-48).

The lateral immediate movement is called *immediate side shift (ISS)* and often, if not taken into account, can cause greater interference in laterotrusion than the progressive component.

An experimental laboratory study of articulators has demonstrated that ISS is conditional on the height of the cusps, the width of the fosse, and the orientation of the sulci. Progressive increments of ISS involve a fossa design that is more extensive and with a reduced cuspal morphology⁸³ (Fig 4-49). Therefore, the articulator on which the prosthesis is prepared must respect and predict ISS.

Simulation of movements (articulators)

Articulators are instruments that can reproduce the occlusal relationship of the two arches both statically and dynamically.⁸⁴ Articulators can be classified as *fixed hinge*, *average value*, *fully adjustable*, or *semiadjustable*.

Fixed hinge articulators (Fig 4-50) have two rigid arches united by a hinge and sometimes have a screw for adjusting the distance between the arches. They allow only a pivotal opening

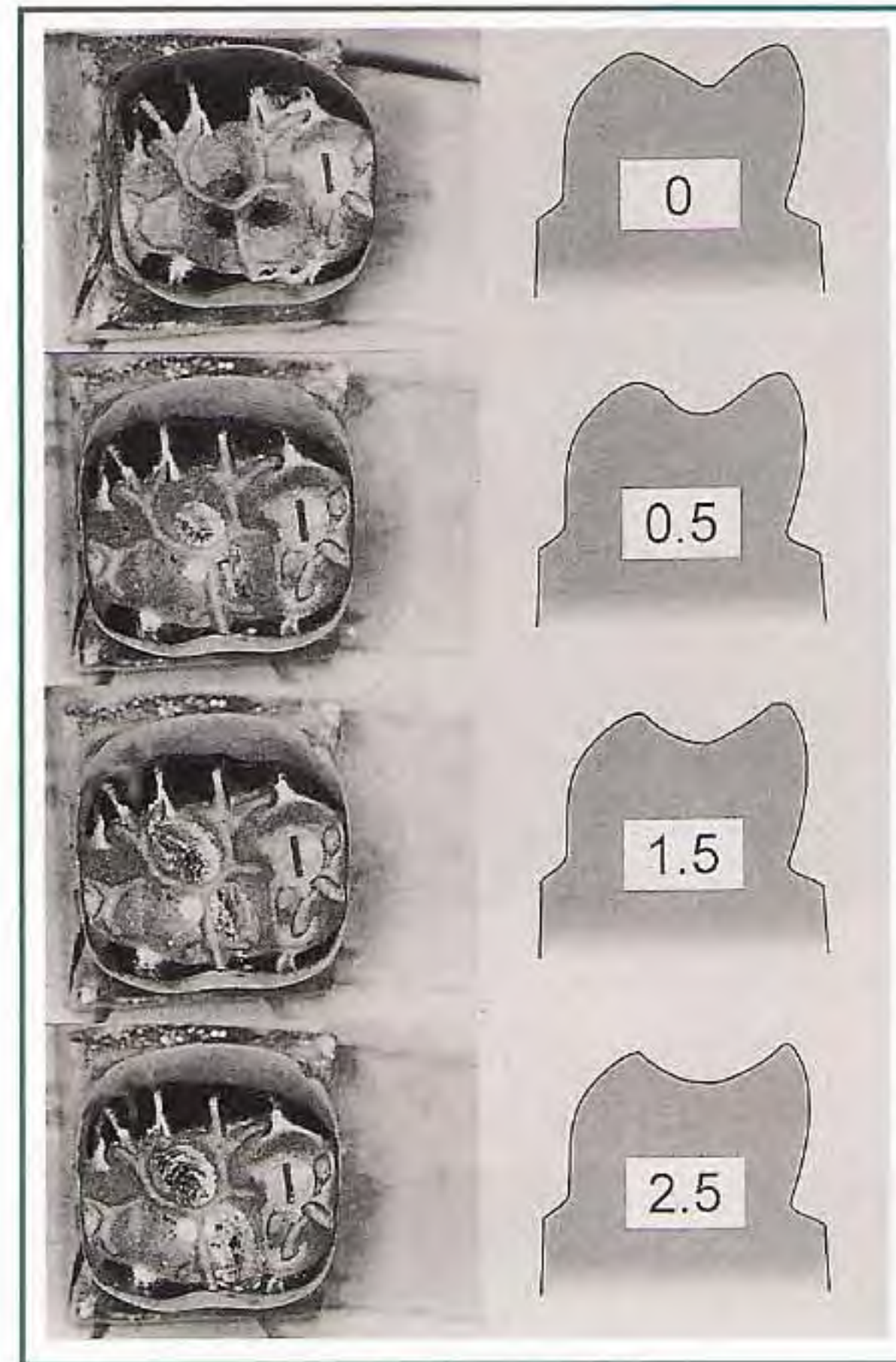


Fig 4-49 Relationship between occlusal morphology of a molar and progressive increments of immediate side shift (from 0 to 2.5 mm). In the left-hand column, the cusps have been substituted with a rotating bur that has widened the fossa of the opposing molar as the immediate side shift increases. The right-hand column shows the sectioned teeth. Note the resulting concave aspect of the occlusal anatomy. (From Mani et al.⁸³ Reprinted with permission.)

on a horizontal axis, from which the distance of the casts is arbitrarily determined and is certainly less than the distance between the TMJ and the patient's teeth. Such models are not able to simulate mandibular movements and the various positions other than centric occlusion, so they cannot be used for occlusal diagnosis.

Average value articulators (Fig 4-51) can reproduce lateral and protrusive movements and have anatomic dimensions. However, the imposed dimensions are statistically determined as the average values and cannot be regulated in certain functions. In clinical practice, use of fixed hinge or average value articulators is limited to the preparation of a single crown and small fixed partial dentures that can be adapted to the existing intercuspal positions; they cannot be used for restoration where contacts are different from centric occlusion, and the patients must have anterior guidance adequate to guarantee an immediate disclusion for both protrusive and lateral movements. It is also possible that prostheses made using these types of articulator will have to be adapted to the patient's mouth to eliminate any interferences.



Fig 4-50 Occlusal (fixed hinge) articulator.



Fig 4-51 Average value articulator.

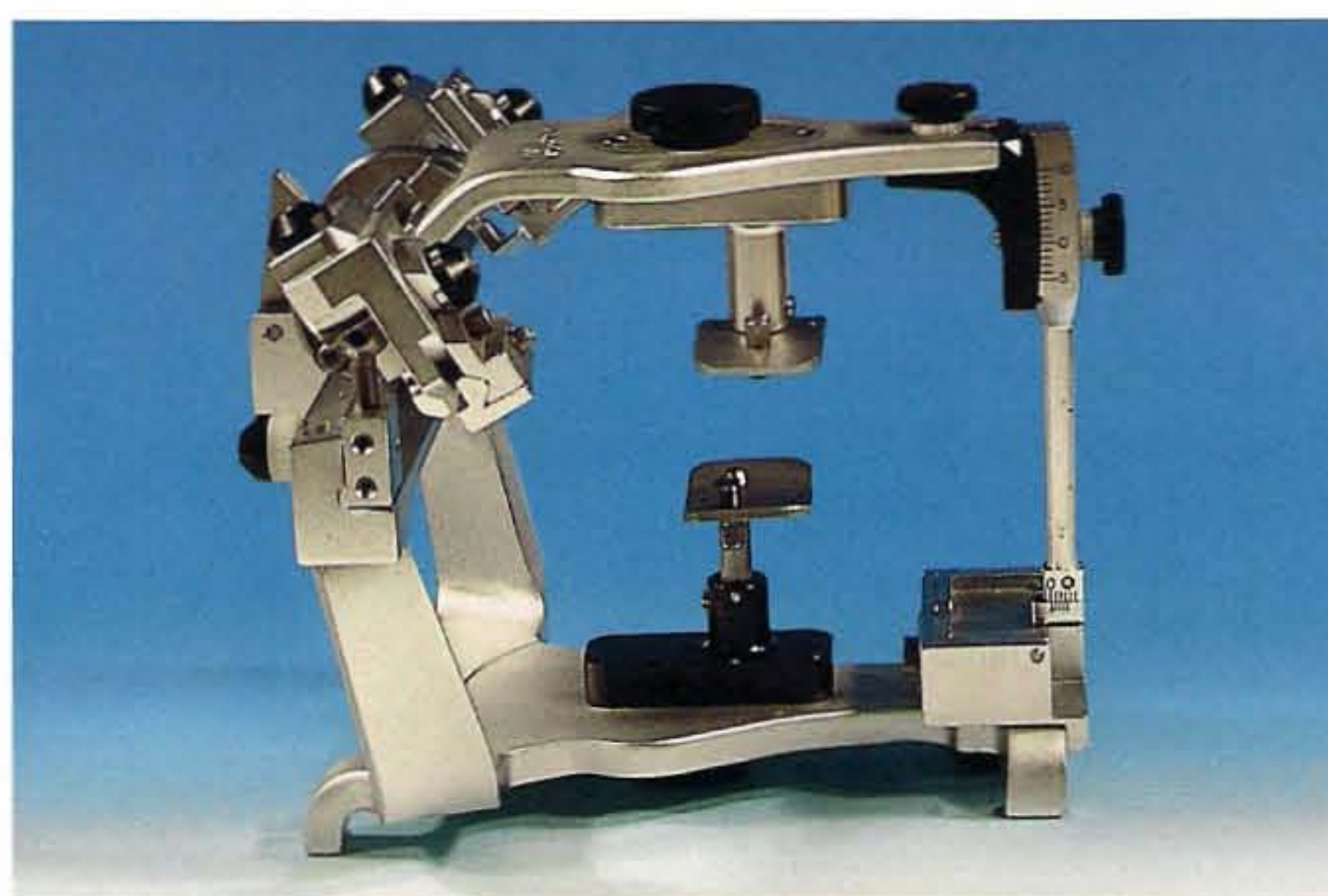


Fig 4-52 Fully adjustable articulator.

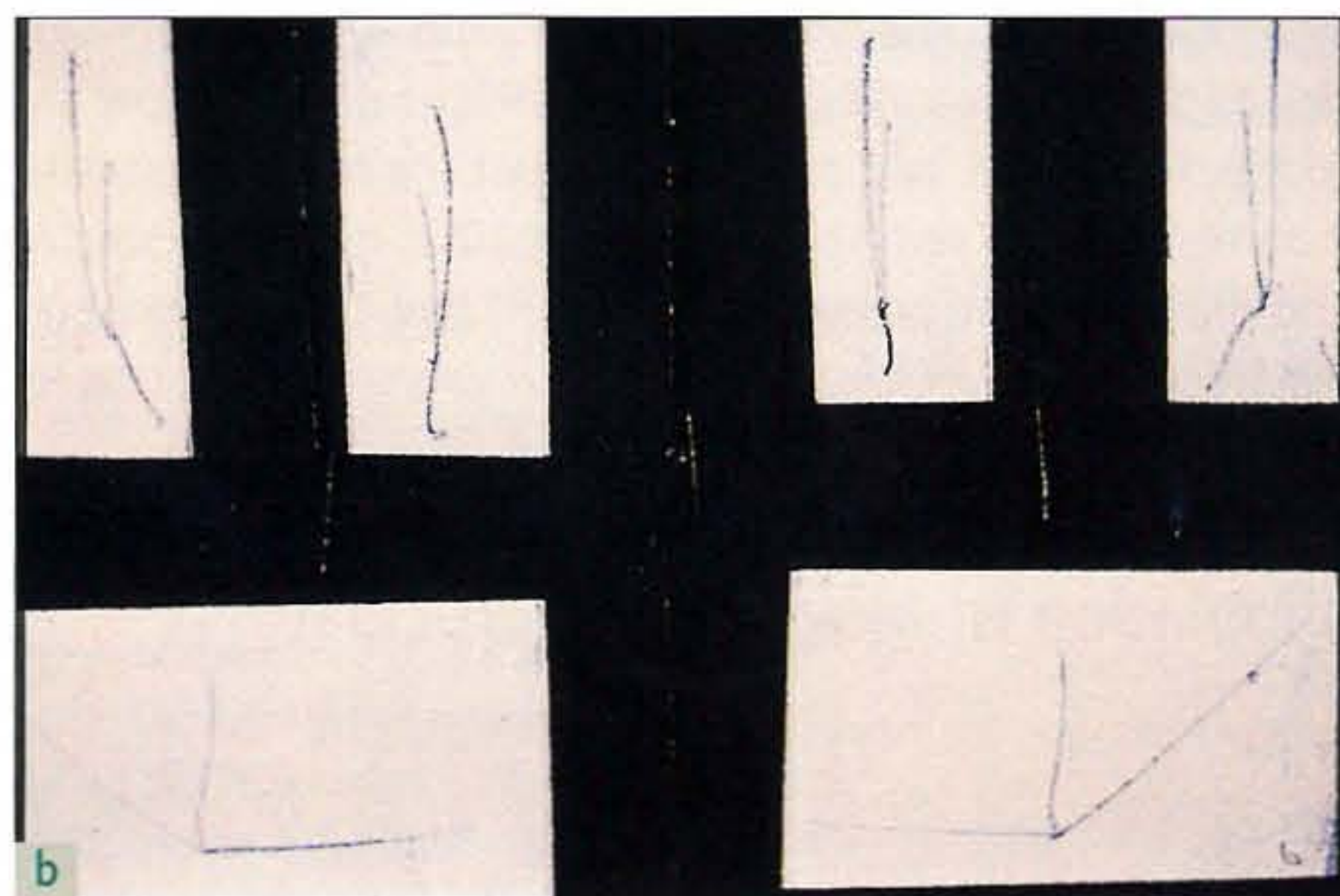
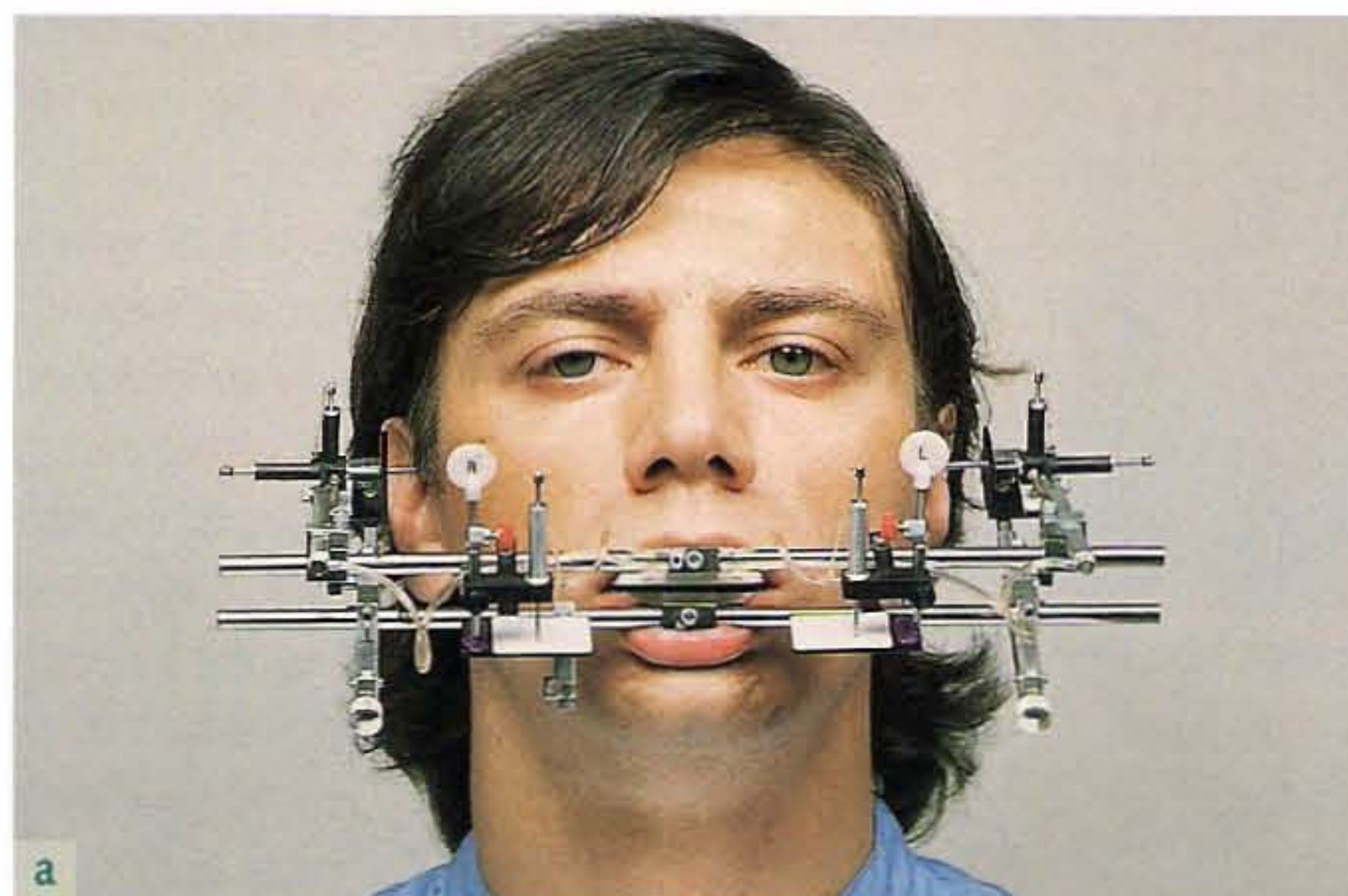


Fig 4-53 (a) Pantograph and (b) pantographic registration. (From Preti and Pera.⁸⁵ Reprinted with permission.)

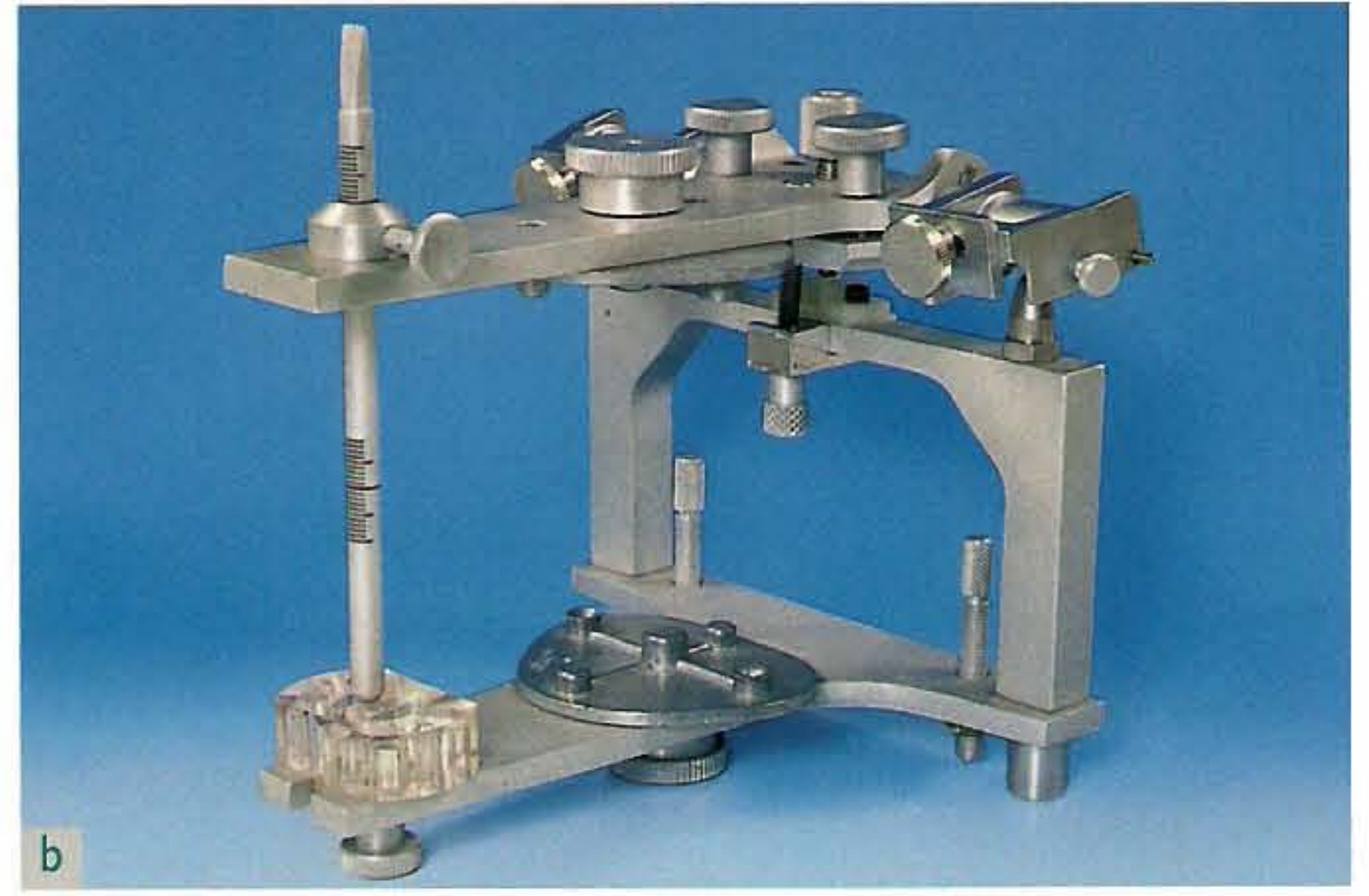
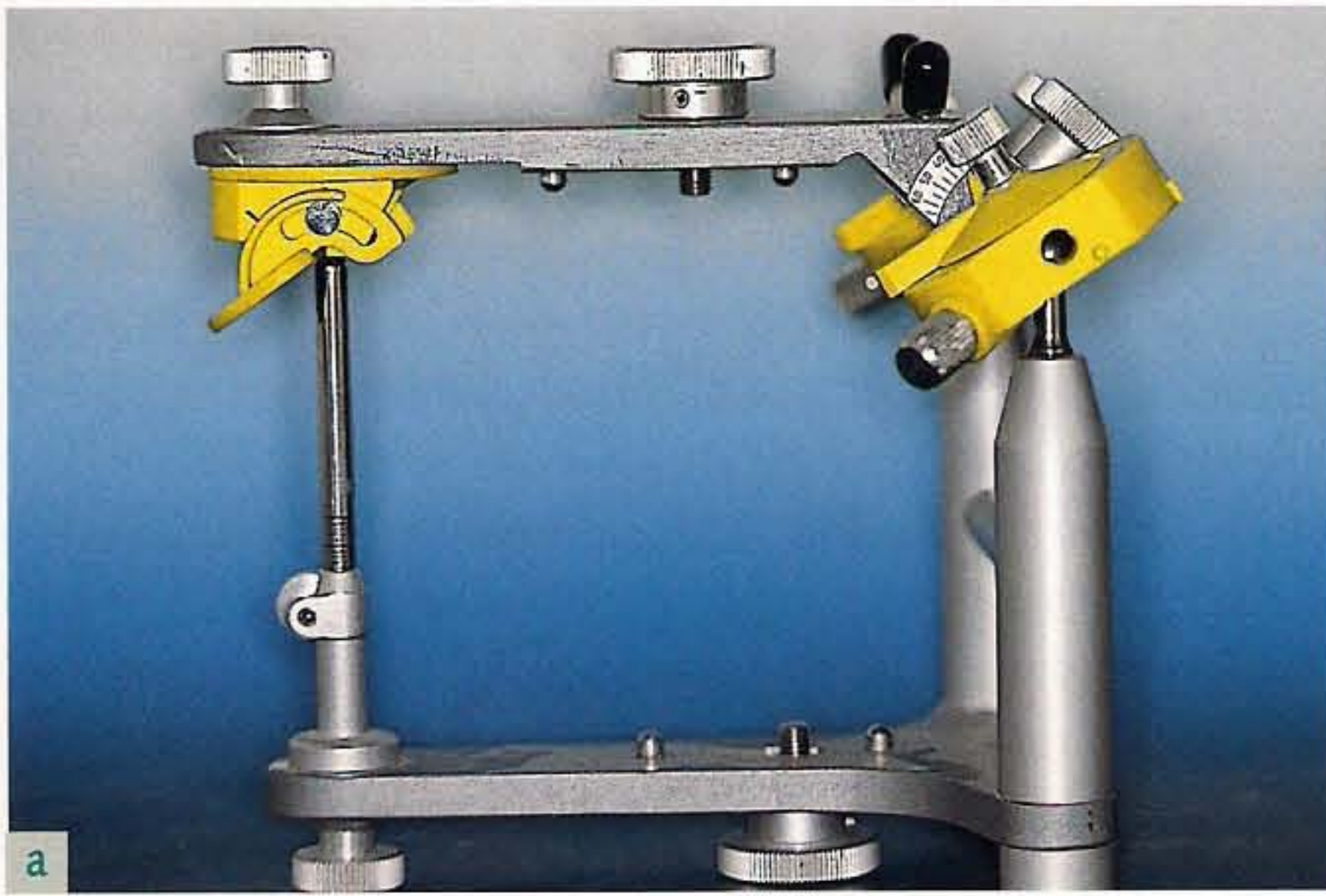


Fig 4-54 (a and b) Semiadjustable articulators. (From Preti and Pera.⁸⁵ Reprinted with permission.)



Fig 4-55 Condylator articulator.

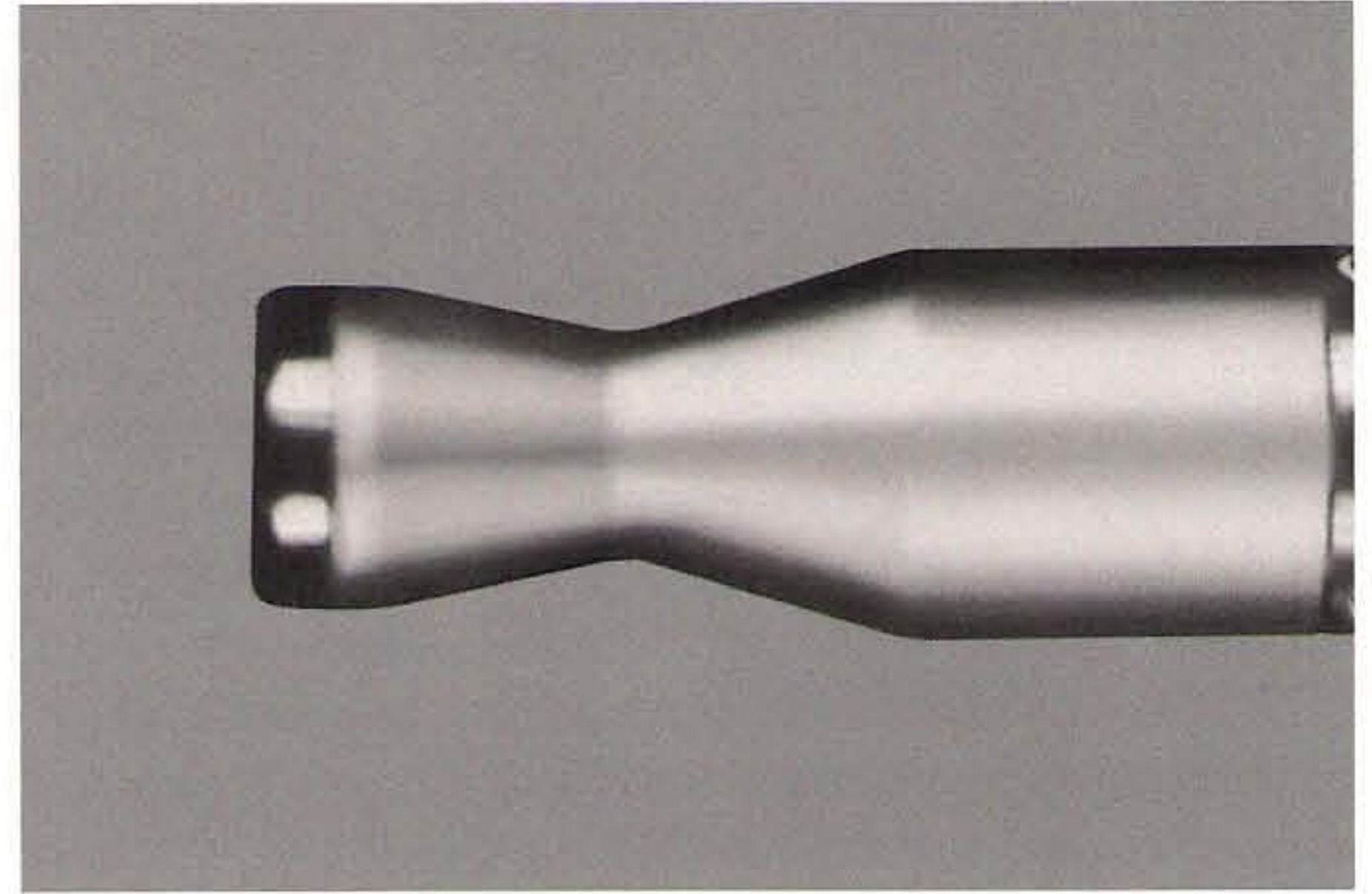


Fig 4-56 Condylar structure with contrapositioned double cones. (From Preti and Pera.⁸⁵ Reprinted with permission.)

Fully adjustable articulators (Fig 4-52) are able to reproduce all movements, including immediate lateral and progressive movements as well as the curvature and direction of the sagittal condylar trajectory. In addition, the intercondylar distance is totally adjustable. To allow use of this articulator, it is indispensable to make intraoral and extraoral records with a complex instrument called a *pantograph* (Fig 4-53). Use of this type of articulator in clinical practice is still being investigated; it is employed principally in research.

Semiadjustable articulators (Fig 4-54) permit the adjustment of certain components of movements, while other components are fixed using statistically determined dimensions. The characteristics of this type of articulator allow the instrument, which is fairly simple to use, to reproduce the most important movements and to transfer the individual hinge axis by using static and dynamic facebows. These are the articulators most commonly used in clinical practice.

When this type of semiadjustable articulator is used, it is necessary to impose an ISS of 1.5 to 2.0 mm and a sagittal condylar trajectory of 25 degrees, thus integrating all the possible individual variations and decreasing the possibility that interferences will be introduced in protrusive and lateral movements. In fact, possible exaggeration of the dimensions of ISS or sagittal condylar trajectory will, at most, provide patients with an occlusion that is more free, while an underestimation could be the cause of undesirable interference in eccentric movements.

With these same proposed dimensions, Gerber⁶⁴ in 1950 created the Condylator articulator (Fig 4-55).

This particular configuration, with a double cone for the articulation, can analyze all types of ISS (Fig 4-56). The Condylator articulator is different from the articulators previously described. The Condylator has the ability to imitate not only the limiting movements of the mandible but also the functional movements. The structure of the condyle is made up of

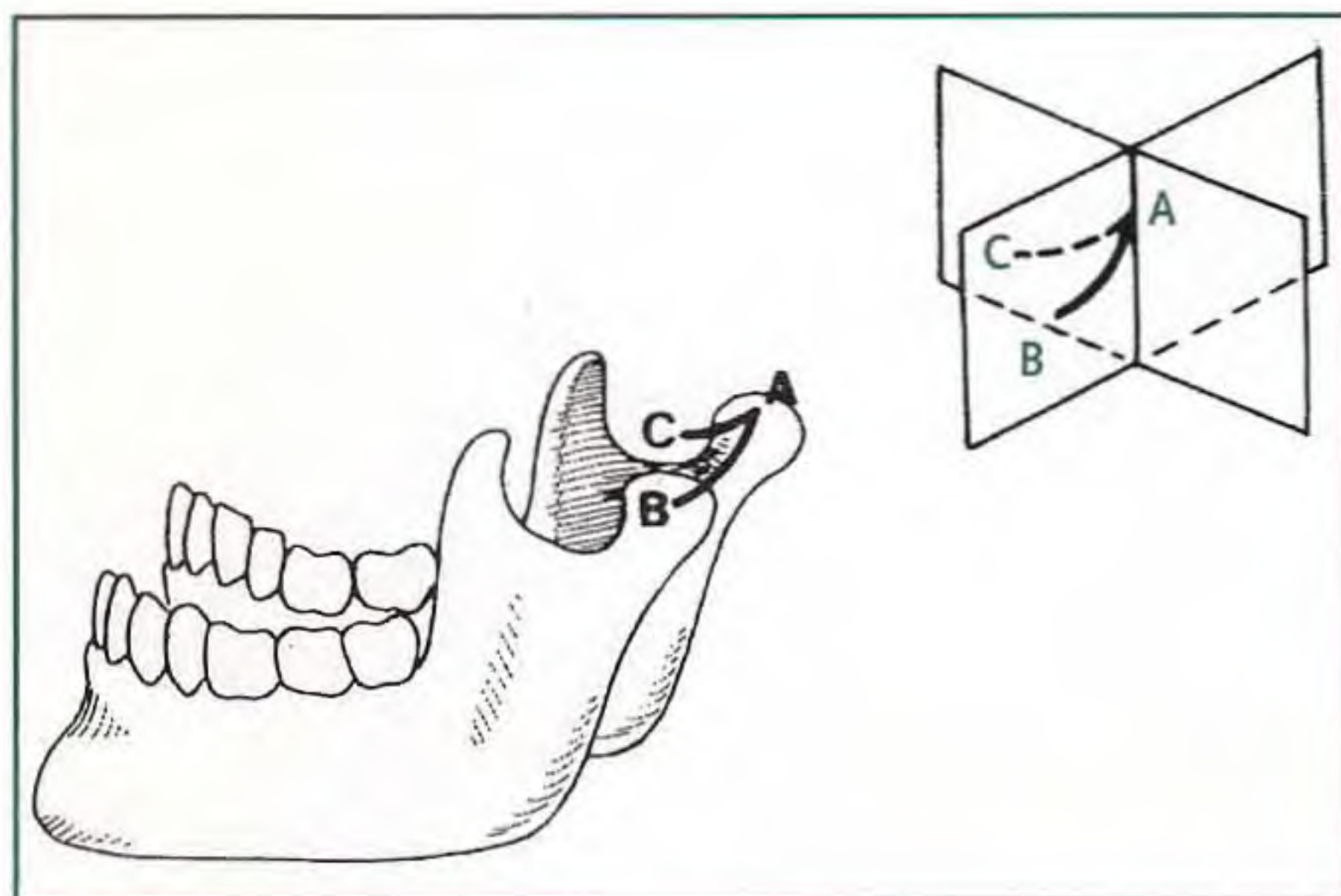


Fig 4-57 The Fischer angle, the angle that is formed on the sagittal plane between the trajectories of the condyle in protrusive and lateral excursions, can vary from 0 to 8 degrees. (A–C) trajectory of the condyle in protrusive excursion; (A–B) trajectory of the condyle in lateral excursion. (From Preti and Pera.⁸⁵ Reprinted with permission.)

two conical protrusions placed together at the smaller ends that imitate, in a negative form, the natural angulations that exist between the working and nonworking portions. This condyle structure is joined to the maxillary part of the articulator, while the mechanical functional imitation of the glenoid fossa is on the lower component of the instrument.

During movements on the nonworking side, the internal part of the double-cone structure forms with the sagittal plane the mean angle of 73 degrees, thus combining all the movement types of ISS. In addition, on the nonworking side, the double-cone morphology incorporates the Fischer angle during lateral and protrusive movements (Fig 4-57).

On the working side, the external part of the double-cone trunk forms an angle of 13 degrees with the intercondylar axis on the frontal plane, thereby permitting the Bennett three-dimensional movement.

By means of an adjustable ring nut, it is also possible to impose the individual inclination of the sagittal condylar trajectory, using registrations made with the kinematic facebow.⁸⁵

Bruxism

Bruxism is defined as a parafunctional activity during the day or night, characterized by clenching or grinding of the teeth or chewing movements in an empty mouth.¹⁸ It can cause extensive wear or damage of the teeth, pain, dental mobility, and trauma to the occlusion.^{86–88} Pain and dysfunction of the masticatory apparatus, together defined as TMDs or cranio-mandibular disorders, have been connected to bruxism, but the

evidence remains controversial¹¹: Unlike the muscles of the limbs, in which eccentric contraction causes pain,⁸⁹ the masticatory muscles do not exhibit such alterations from this type of exercise. However, it is now agreed that the vicious circle of pain-hyperactivity-pain does not exist⁹⁰; furthermore, a great number of people affected by bruxism do not report pain.⁹¹

More recent studies are inclined to consider that diurnal parafunction and nocturnal bruxism (more precisely “during sleep”) are two separate diagnostic entities. The definition of *bruxism* most used and that proposed by the American Sleep Disorders Association is: “disease of the movement of the masticatory system that includes the clenching and grinding of the teeth characterized by periodical and stereotyped movements.” This sleep-related disease is classified as being among the parasomnias.⁹²

Parafunctional activities during the day, such as lip or cheek biting, pushing the tongue against the teeth, sucking the fingers, and nail biting, are all conditions that can lead to functional overloading of the oral apparatus. Diurnal bruxism is not normally associated with grinding movements and may have a different etiology. It is characterized by sustained clenching of the teeth and strong contractions of the masticatory muscles. In either case, the parafunctional action is concentrated explicitly on the masticatory apparatus and has destructive effects that can affect not only the teeth but also dental restorations and thus should be monitored in such patients. Bruxism represents a risk factor for the long-term success of prosthetic rehabilitations and implants. The dentist must recognize patients affected by bruxism and use strategies to monitor the effects of such oral parafunctioning. For clarity, in this chapter the term *bruxism* will be used only to describe bruxism that occurs at night or during sleep.

Epidemiology and diagnosis

Bruxism is found in between 6% and 20% of the population, including children (14%), and it diminishes after the age of 50 years.⁹³ Clenching is reported more frequently (22%) in women than in men. In patients with TMDs, the reported frequency is between 26% and of bruxism 66%.⁹⁴

Diagnosis of bruxism is not easy. Self-reporting or information from partners is not reliable, while studies of dental abrasion, either in the mouth or on casts, cannot establish the origin of such wear or even if it is normal wear for the age of the patient.^{95,96}

Electromyography⁹⁷ may be a limited diagnostic method able to discriminate between clenching and grinding but cannot exclude other activities such as swallowing, myoclonus, somniloquism, tics, or epileptic crises. Only by the creation of an audio and video record can the real type of muscular activity or move-

ments be clarified. This is only possible in a sleep research laboratory. In such an experimental setup, it is possible to demonstrate the rhythmic activity of the masticatory muscles (of lower intensity than bruxism) that is present in 56% of the affected population that attend a center for sleep medicine.⁹⁸ Consequently, rhythmic masticatory muscle activity is considered as part of the normal orofacial behavior that may become pathologic in a proportion of people.

The cut-off level for a diagnosis of bruxism is at least two episodes of noisy grinding; and more than 4 episodes of bruxism per hour of sleep, or 25 bursts of bruxism per hour of sleep and more than 6 bursts per episode⁹⁹ (a *burst* is muscular activation registered electromyographically at the base of parafunctional mandibular movements). With these criteria, the presence or absence of bruxism has been confirmed in 83% of patients affected by bruxism and in 81% of asymptomatic people, respectively.

Clinical diagnostic criteria that have been validated using polysomnography are reports by the subject or his or her family of frequent grinding or tooth clenching during the night for a period of at least 6 months, associated with at least one of the following signs: noises associated with bruxism, reported by the family; abnormal wearing of the teeth; frequent tiredness, fatigue, or pain in the muscles in the morning; or hypertrophy of the masticatory muscles. The following signs, even if frequent, are not necessary to establish a diagnosis:

- Mobility of the teeth in the absence of orthodontic therapy or periodontal disease
- TMD, noises, or clicking
- Imprints of the teeth on the tongue or cheek mucosa
- History of tension headaches
- Damage to teeth, including cervical lesions; fractured enamel, often vertical in canines and the cusps of molars; complete fracture of crowns; and dentinal hypersensitivity

Bruxism is often associated with other disorders of sleep, such as periodic myoclonus or obstructive apnea that might negatively affect daytime vigilance as a consequence of serious sleep disturbances. In this light, it would seem useful when approaching patients with bruxism to ascertain the presence of daytime sleepiness during the history.

Tooth wear

The principal effect of bruxism is abnormal dental wear as a result of grinding and clenching.¹⁰⁰ This wear may be only on one tooth (Fig 4-58), in restricted areas (Fig 4-59), or throughout the entire mouth (Fig 4-60). Generally, it affects the incisal margins of the anterior teeth, the occlusal surfaces of the posterior teeth, or both. The surfaces of the incisal teeth become polished and shiny with sharpened margins (Fig 4-61) that can



Fig 4-58 Parafunctional activity with an effect on a single tooth; the effect of grinding has created a groove in the lateral incisor that coincides perfectly with the mesial surface of the opposing canine.

traumatize the tongue and cheeks; such wear on the anterior teeth often becomes an esthetic problem. In premolar and molar teeth, the wear on the cusps results in reduced inclination, creating wide and flat surfaces (Fig 4-62). Severe wear can exceed the interproximal contacts, resulting in the formation of diastemas and facilitating food impaction, or reduce the VDO¹⁰¹ (Fig 4-63).

Dental wear can cause pulpal problems (Fig 4-64), sensitivity to thermal stimuli, pulpitis, and sometimes pulpal necrosis; teeth subject to grinding and clenching may fracture, especially if the cusps are weakened and a restoration is undermined. Restorations, whether a single tooth or a complex rehabilitation, can be seriously damaged (Fig 4-65).

Etiology

Most theories attribute bruxism to a multifactorial etiology^{11,100} and discriminate between peripheral factors (anatomy, dental occlusion, receptorial input) and central factors (CNS and psychological). Ramfjord's theory,¹⁰² which affirms that occlusal interference is an important etiologic factor, is based on electromyographic research that is debatable and unconfirmed, even though it has formed the basis of therapy for bruxism for decades.

Recent scientific studies have shown that removal of occlusal interference does not modify bruxism, and that inserting artificial interference diminishes, rather than increases, muscular activity in 90% of subjects.¹⁰³ In addition, the association between bruxism and mandibular asymmetry¹⁰⁴ or bizygomatic and cranial¹⁰⁵ width has been refuted¹⁰⁶. No difference has been documented between those with bruxism and those with-



Fig 4-59 (*a and b*) Parafunctional activity that is expressed on a group of teeth; in this case, the parafunctional activity results in damage to the palatal surfaces of the maxillary incisors.



Fig 4-60 Parafunctional activity that affects the entire occlusal plane; note the severe destruction the teeth.



Fig 4-61 Results of dental abrasion; note the exposure of dentin and the presence of sharp-edged enamel at the periphery.



Fig 4-62 Parafunctional activity in a molar; note the deep occlusal fossa within the dentin.



Fig 4-63 Enlargement of the inset in Fig 4-60. Extreme destruction of the occlusal plane, leading to the loss of vertical dimension and the reduction of the prosthetic space.



Fig 4-64 With the loss of the dental hard tissues, the pulpal tissues are exposed.

out who were examined for 26 occlusal parameters by polysomnography and 25 anatomic variables.

Bruxism has been studied in relationship with the physiology of sleep, suggesting that it is a phenomenon related to fluctuations in the profundity of the level of sleep.¹⁰⁷ Recent studies of non-rapid eye movement sleep have demonstrated that there is a relationship between episodes of bruxism and arousal (or diminishing profundity of sleep) as well as an increase in cardiac rhythm frequency and movement of the limbs.¹⁰⁸ This finding suggests that arousal is a physiologic mechanism that “allows” bruxism, similar to actions in other parasomnias.¹⁰⁹ However, the sleep of those with bruxism is substantially normal, with only very slight differences at microstructural level from normal subjects.

Controlled clinical studies with single photon emission computed tomography have indicated a possible role of the central dopaminergic system in the genesis of bruxism.¹⁰⁹ Asymmetry in the expression of dopaminergic receptors D2 at the level of the mesencephalic nucleus stria has been documented in patients with bruxism, similar to that found in those with other diseases of movement, for example, spasmodic torticollis. Low doses of bromocriptine have diminished bruxism,¹¹⁰ while an increase in bruxism has been associated with habitual use of dopamine antagonists,¹¹¹ levodopa,¹¹² and selective serotonin reuptake inhibitors.¹¹³ Other forms of bruxism are linked with voluntary use of substances active at the CNS level, such as 3,4-methylenedioxy-N-methylamphetamine (narcotics of the ecstasy group)¹¹⁴ and nicotine.¹¹⁵ Smokers have double the frequency of bruxism, with five times the number of bruxism episodes per night experienced by control subjects.¹¹⁵ Also, in this case, an increase in dopaminergic tone might be hypothesized to exist.

Psychological factors (stress, anxiety, and aggressiveness) have been considered to be cofactors in the etiology of brux-



Fig 4-65 Fracture of an entire ceramic crown because of parafunctional activity.

ism. Even if these factors are difficult to measure, patients with bruxism have been characterized as perfectionists with a tendency to increased aggressiveness and anxiety.¹¹⁶ However, psychometric tests (Minnesota Multiphasic Personality Inventory)¹¹⁷ and studies of stress¹¹⁸ have found no or small, nonsignificant correlations.

Studies of animal models have recently revived attention to the possible role of peripheral factors in the central mechanisms discussed. In mice with bruxism, acute and massive changes in the incisors have resulted in asymmetry of the dopaminergic system in the basal ganglia.^{119,120} In humans, occlusal variations have not been correlated with asymmetry of D2 striatal receptors.^{106,110}

In summary, acute bruxism that occurs during nighttime and sleep is now considered an exaggerated manifestation of otherwise normal motor activity of the masticatory muscles, classifiable as parasomnia. The etiology is multifactorial, and the peripheral factors (dental occlusion and anatomy of the orofacial system) play only a minor role. Analogous to other parasomnias, bruxism is related to rapid fluctuations of profound sleep. There are also other indications that patients with bruxism exhibit modifications of the dopaminergic balance at the level of the CNS.¹²¹

Therapy

At present, there are no specific cures for bruxism. The principal objective is control and prevention of damage to the orofacial structures. These indications are also valid for protecting prosthetic and implant rehabilitations to prevent prosthetic failures linked to parafunctional overload. The possible treatment strategies are interventions to modify the behavior of patients, use of occlusal guards, and prescription of pharmaceutical agents.^{93,122}

Box 4-10 Instructions for patients with nighttime bruxism

- Relax for at least 60 to 90 minutes before going to bed; avoid getting involved in emotional discussions and try to forget about worries and disturbing thoughts. In other words, try to detach mentally and physically from daily activities.
- Learn relaxation techniques to use during the day and before going to sleep.
- Maintain good physical condition, but avoid excessive exercise after 6:00 PM.
- Avoid heavy meals and consumption of excessive alcohol and coffee before going to bed.
- Stop smoking after 7:00 PM.
- Create a comfortable atmosphere for sleeping.

Behavior modification

The clinician should provide advice to the patient on lifestyle changes that may reduce the occurrence of bruxism (Box 4-10).

Use of occlusal guards

Since the reappraisal of the role of occlusal factors in the etiology of bruxism, only reversible methods of therapy, such as occlusal splints, are used in an effort to protect the orofacial structures.^{50, 123}

Rigid or soft splints may be used. Soft splints, because of the rapid deterioration of the material, should only be used for brief periods. Rigid splints may be indicated for severe parafunctional activity, even if not all patients with bruxism find their use a relief. In fact, it has been noted that about 20% of patients have an increase in electromyographic activity when they wear an occlusal splint; such splints have been demonstrated to reduce the muscular activity level but not the frequency of the motor activity of nighttime bruxism.^{124,125}

Pharmacologic therapy

Use of benzodiazepine and other drugs active at the CNS level has been proposed; however, no controlled studies have been made. The use of these drugs for long periods is contraindicated in patients who are healthy and do not need to take drugs for other reasons.

Prosthetic considerations

Prosthetic treatment of patients affected with bruxism, given the destructive tendencies of the habits, is a challenge to the dentist. It is, however, possible to respond with:

- A correct diagnosis of the patient's bruxism.
- The selection of a treatment plan that takes into account the patient's parafunctional activity, which could result in overload of centric relation during clenching or involve eccentric movements during grinding. The dentist must choose a prosthetic rehabilitation plan that avoids risky biomechanical conditions and avoids concentration of destructive parafunctional forces on a few or single teeth. This may involve selecting the occlusal design that is best able to distribute the parafunctional loads.
- The use of materials that are best able to resist the forces involved in the parafunctional activities and that will not accelerate the process of dental wear.

As indicated in the literature, prosthetic materials must have a level of wear that is approximately the same as the usual wear of tooth enamel, about 20 to 40 μm per year.¹²⁶ Mahalik et al,¹²⁷ in an in vitro study, found that enamel opposed to feldspathic ceramic wears 2 to 4 times more rapidly than enamel opposed to acrylic resin and 17 times more rapidly than enamel opposed to a gold alloy. Ekfeldt and Øilo,¹²⁸ studying a sample of patients with bruxism, observed a great loss of dental substance when enamel was opposed to feldspathic ceramic. It is clear that ceramic must be used with caution.¹²⁹ Furthermore, esthetic materials that are used as alternatives to ceramic, such as acrylic resins or resin composites, do not guarantee the mechanical resistance properties over the long term and often fracture or detach from the metallic support; this can also occur with ceramic or metal-ceramic prostheses. For these reasons, when choosing materials, the clinician must balance between the risks of fracture and the risks of accelerated wear of either the rehabilitation or the opposing teeth. The clinician also must put into practice the previously described therapeutic means of controlling the effects of parafunctional activity.

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5

The Oral Cavity as an Ecosystem: Aspects Relevant to Prosthetic Treatment

The state of oral health of the individual is the result of a balance between humoral and cellular factors of the immune system and bacterial flora. Dental pellicle, plaque, and salivary fluid are responsible for this balance, and together they constitute the so-called ecosystem of the oral cavity (Fig 5-1). These factors are important in the overall functioning of the oral cavity. Knowledge of the physiologic and microbiologic characteristics is fundamental to understand the consequences of changes in this balance. Local homeostasis is also influenced by interactions that occur between the oral environment and materials used for therapeutic purposes, which may cause variations in the composition of the microflora and thus have repercussions for the health of the oral mucosa, periodontium, and hard tissues (Fig 5-2).

Much effort and research have been expended in optimizing designs and techniques for creating artificial prostheses with ever better and longer-lasting results. It is essential to consider the interactions with the oral environment into which they are introduced so as to avoid treatment failure. This chapter aims to rationally integrate the choices of therapy, suitable materials, and

types of restoration according to the needs of the patient. The first part of the chapter provides a brief introduction to the characteristics of the oral ecosystem in relation to maintenance of oral cavity health. The chapter then analyzes the interactive phenomena between the patient and prosthetic materials used in rehabilitation, and concludes by underlining the most relevant biologic aspects to be considered when clinical treatment is planned.

Components of the Oral Ecosystem: Acquired Pellicle, Dental Plaque, and Salivary Fluid

Physiology of the acquired pellicle and dental plaque

The acquired pellicle or film, an organic protein, covers the surface of the teeth. The film is formed, after tooth eruption, to allow selective absorption of the salivary protein by the enam-

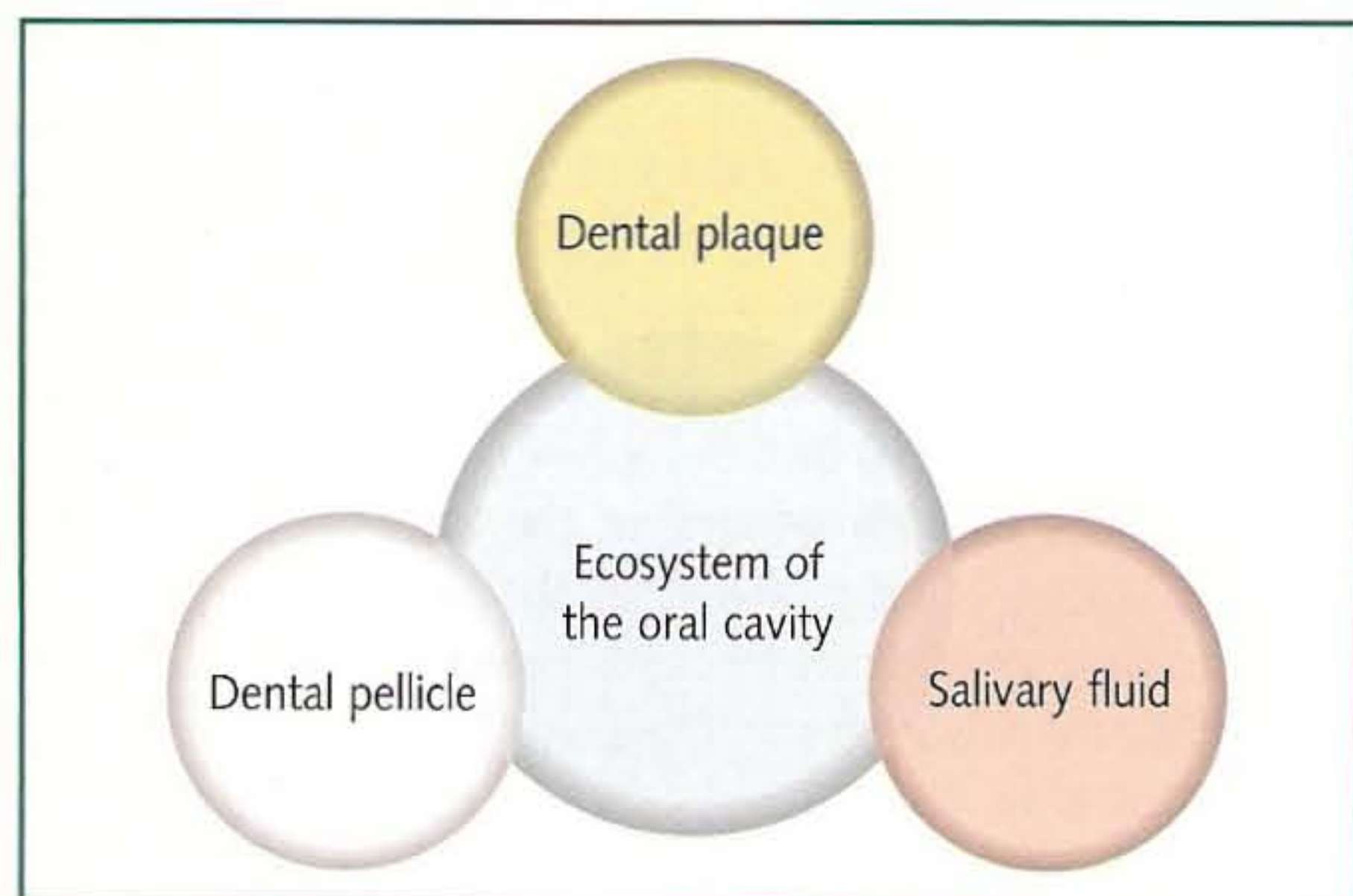


Fig 5-1 The ecosystem of the oral cavity is composed of a dental pellicle, plaque, and salivary fluid.

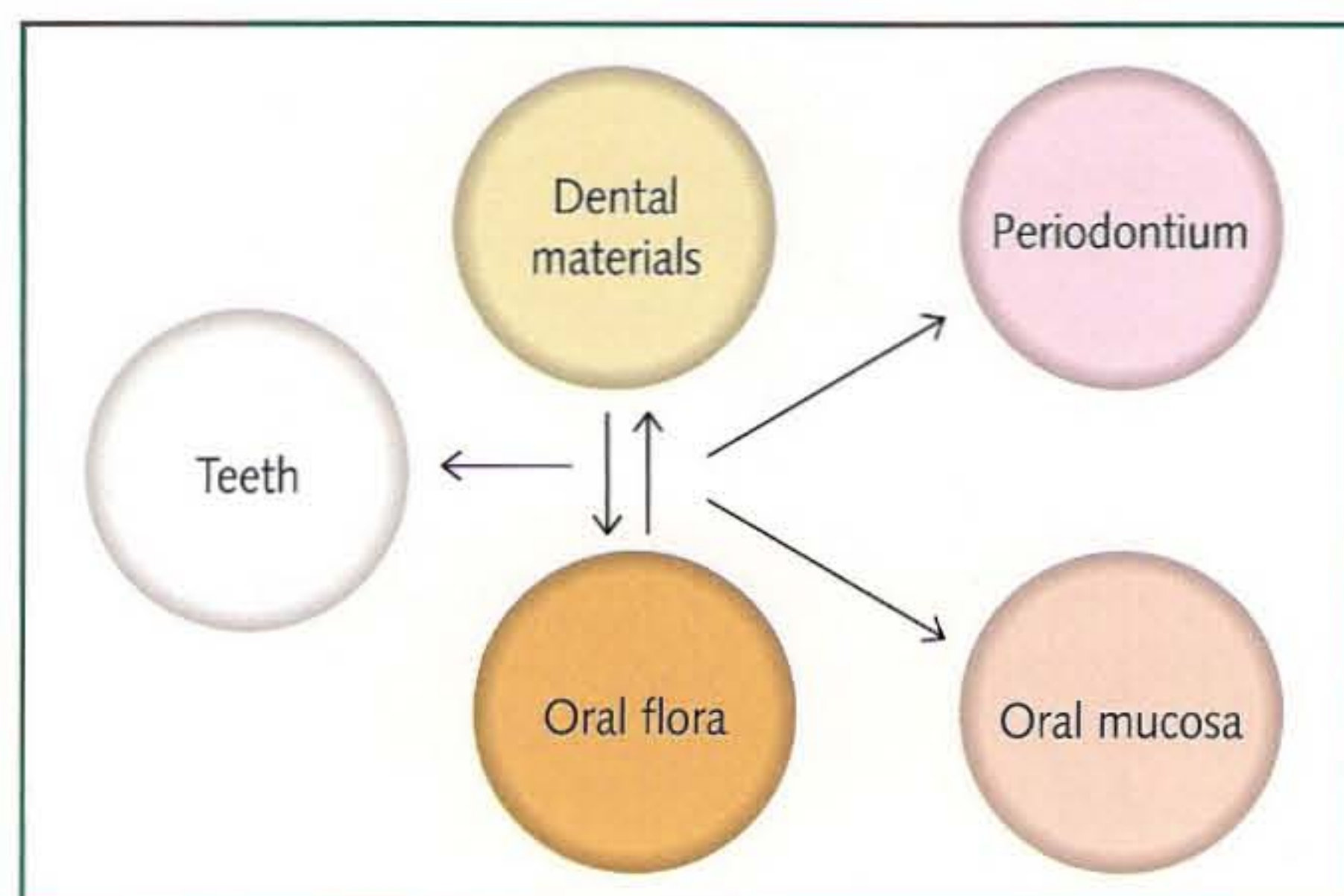


Fig 5-2 The interactions between dental materials and the oral environment influences local homeostasis, with repercussions on the state of health of the mucosal, periodontal, and dental tissues.

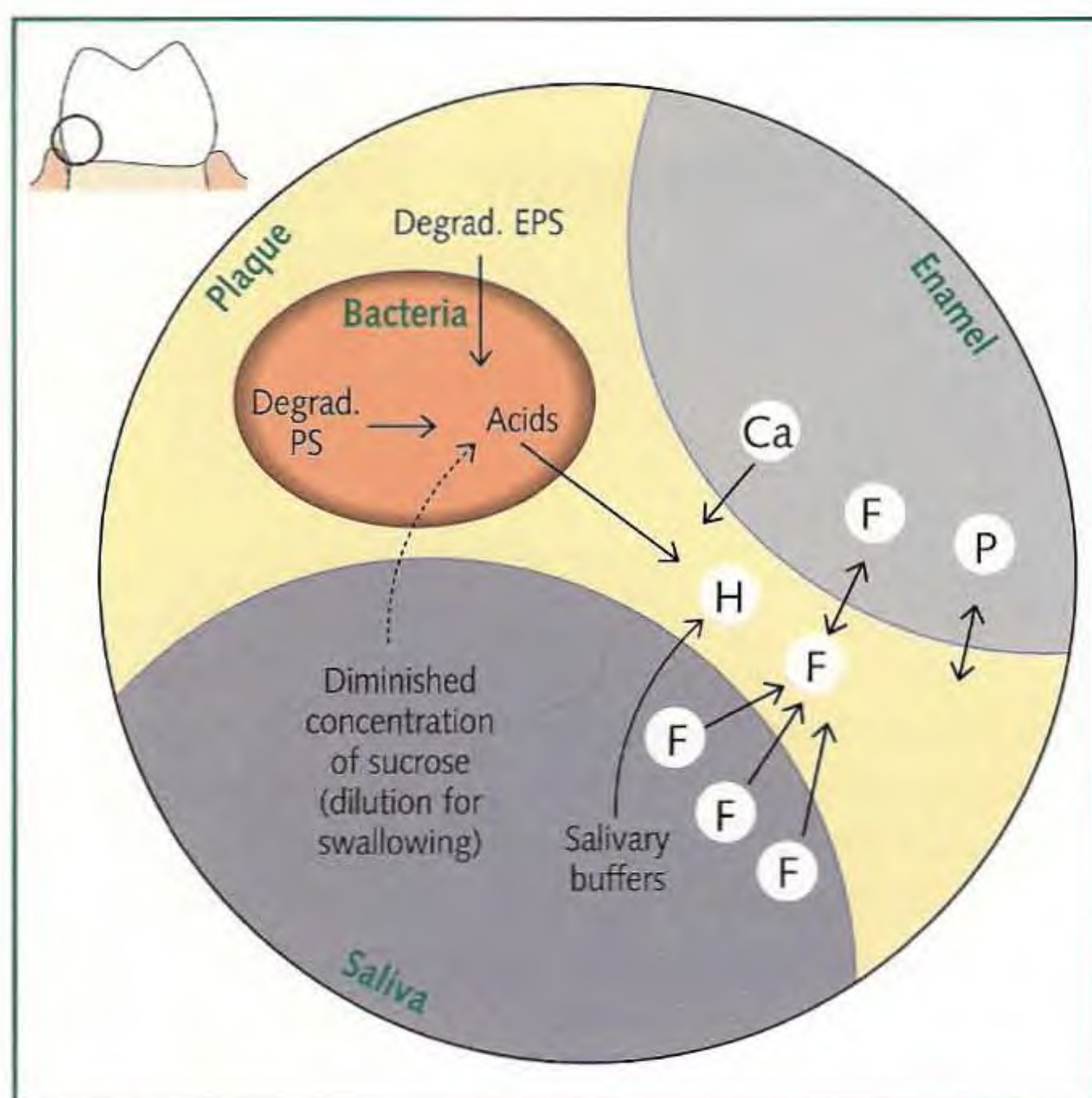


Fig 5-3 The oscillation of pH resulting from the degradation of intracellular polysaccharides (IPS) and the extracellular polysaccharides (EPS) is neutralized by the buffering action of the saliva, which favors the maintenance of the local equilibrium of ionic exchange.

el. Studies from scanning electron microscopes have shown that the pellicle does not simply cover the surface of the teeth but penetrates deep into the enamel with filamentary attachments, especially in the approximal areas. Its primary function is to protect the enamel, probably through a mechanism that slows down the degree of disintegration of the hydroxyapatite.¹⁻⁸ Furthermore, it helps to minimize friction between teeth, limiting the damage caused by parafunctional habits and abrasion. The enamel film is very important in the formation of plaque (which is thought to make up the substratum): Its molecular surface facilitates the selective absorption of nonpathogenic bacteria, encouraging adhesion to the teeth.

Dental plaque is called a *biofilm* in modern terminology, that is, an environment that has its own natural dynamic determined by its own ecosystem. The biofilm has protective properties with respect to the oral tissues and provides an environment for the bacteria, which are protected from attack from the immune defense system of the organism.^{9,10} Furthermore, through this film, toxic products of bacterial metabolism are excreted, the oscillations of the intraoral pH are buffered, and fluoride gained from the diet is deposited as part of the defenses of oral hygiene. In this way, dental plaque provides a physiologic and functional basis for the remineralization mechanisms of the enamel. Furthermore, plaque favors the penetration of immunoglobulin G (IgG), which is produced in the intestines,

carried through the hematic circulation, and secreted through the crevicular fluid,¹¹ and thereby strengthens the local defense mechanisms (Fig 5-3).

Plaque is made up of an organic matrix that is firmly attached to the surface of the teeth, thanks to the presence of particular protein, which has a great affinity with the calcium ions of the enamel. The composition of the oral flora is regulated by a series of antibacterial factors present in the saliva, of which some, such as mucin and immunoglobulin A (IgA), have the capacity of selectively bonding with microorganisms. This suggests a direct involvement of these components in the process of bacterial adhesion.^{12,13}

The degree of virulence of the bacteria varies from individual to individual and, in the same individual, differs in the various zones of the mouth. The bacteria are extremely selective in their bonds and are particularly choosy when it comes to tissues and individuals: This can be explained by the uniqueness of structure of the adhesion sites.

The selectivity of the absorption process for the dental surfaces and soft tissues depends on adhesins, a highly specific system of recognition, present on the bacterial surface and able to identify and interact with specific sites of the adhesive film, with epithelial cells, and with the tongue.^{2,13,14}

The increase of plaque is linked to a mechanism of intrinsic autoregulation, based on the ecological relationships (competition or symbiosis) that exist between different microbial species. Some bacterial species are commensal and, in conditions of balanced growth and integrity of the host tissues, do not interfere with other bacterial strains of the plaque. Others, for example, *Streptococcus mutans*, are able to produce substances that inhibit the growth of potentially pathogenic bacteria, contributing in this way to the maintenance of the local equilibrium.¹⁴

Composition and function of the salivary fluid

Salivary fluid is a complex mixture of components with numerous origins: major salivary glands (parotid, submandibular, and sublingual), minor or accessory glands, and crevicular liquid. The cellular structure of the various glands and their relative types of secretion are shown in Fig 5-4.

About 90% to 95% percent of the total volume of daily secretion (about 1 L) is produced by the major salivary glands; the remaining amounts (varying between 5% and 10%) are secreted by the minor salivary glands positioned in the oral cavity^{15,16} (Box 5-1).

Salivary secretion is subject to physiologic variations that are reactions to various stimuli and conditions¹⁵⁻¹⁷ (Fig 5-5). The constituents of the salivary fluid vary in relation to its function (Box 5-2).

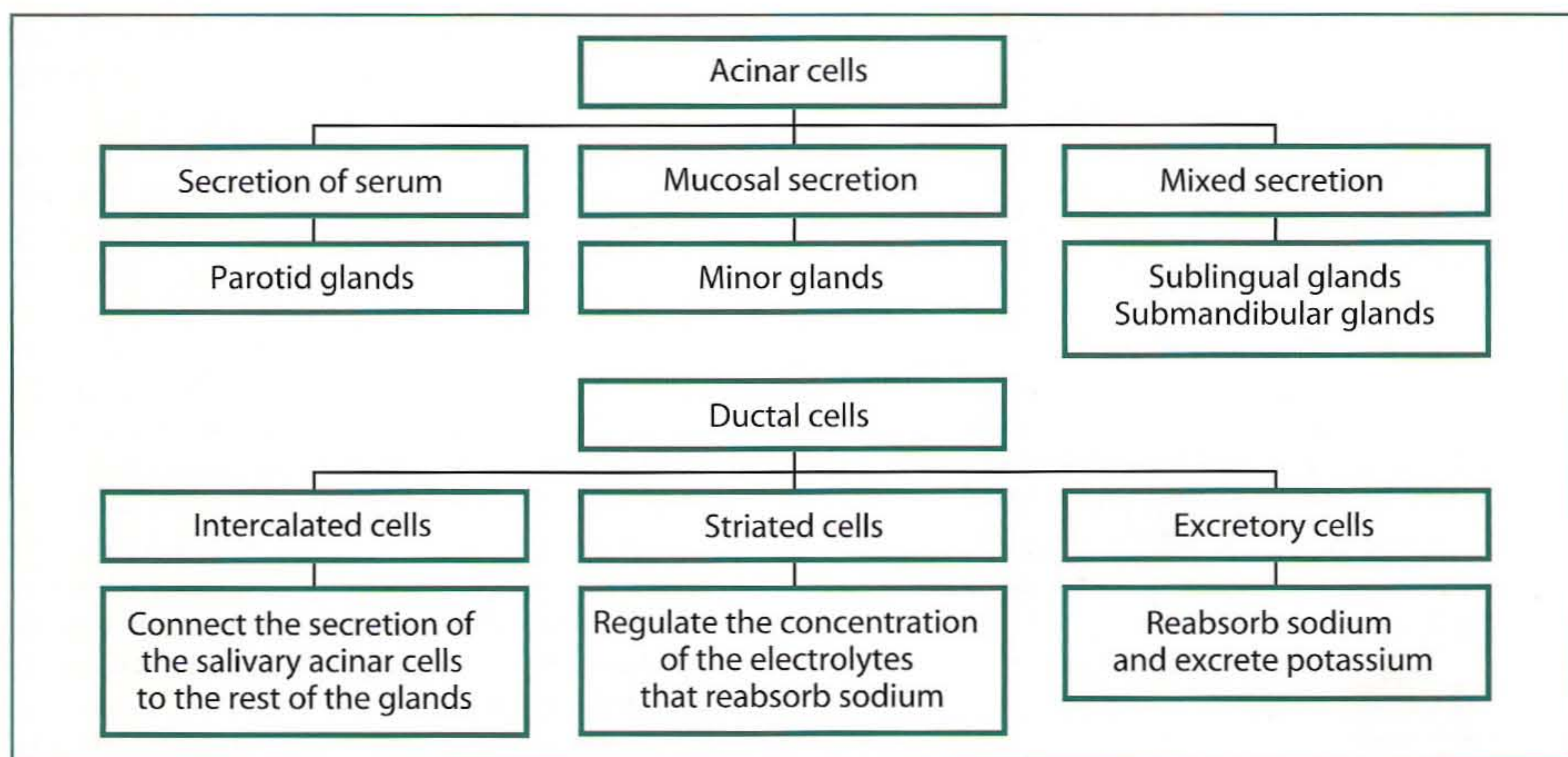


Fig 5-4 Cellular constituents and type of secretion of the various salivary glands.

Box 5-1 Characteristics of salivary flow

- Basal salivary flow: 0.38 ± 0.21 mL/min
- 70% from the submandibular glands
- 16% from the parotid glands
- 6% from the sublingual glands
- 8% from the mucosal glands
- Stimulated salivary flow: 4.3 ± 2.1 mL/min

Box 5-2 Constituents and function of saliva

Protective functions

- Lubricant: Mucins, proline-rich glycoproteins, water
- Hydrating: Mucin, water
- Detergent: Water
- Antimicrobial: Lysozyme, lactoferrin, mucins, cystatins, histatins, secretory IgA, proline-rich glycoproteins, lactoperoxidase
- Mucosal integrity: Electrolytic mucins, water
- Buffering: Bicarbonate, phosphate, protein
- Remineralization: Calcium, phosphate, proline-rich proteins, statherin

Alimentary functions

- Preparation of food: Water, mucins
- Digestion: Amylase, lipase, ribonuclease, protease, water, mucins

Taste: Water, gustin

Phonetic functions

- Phonation: Water, mucins

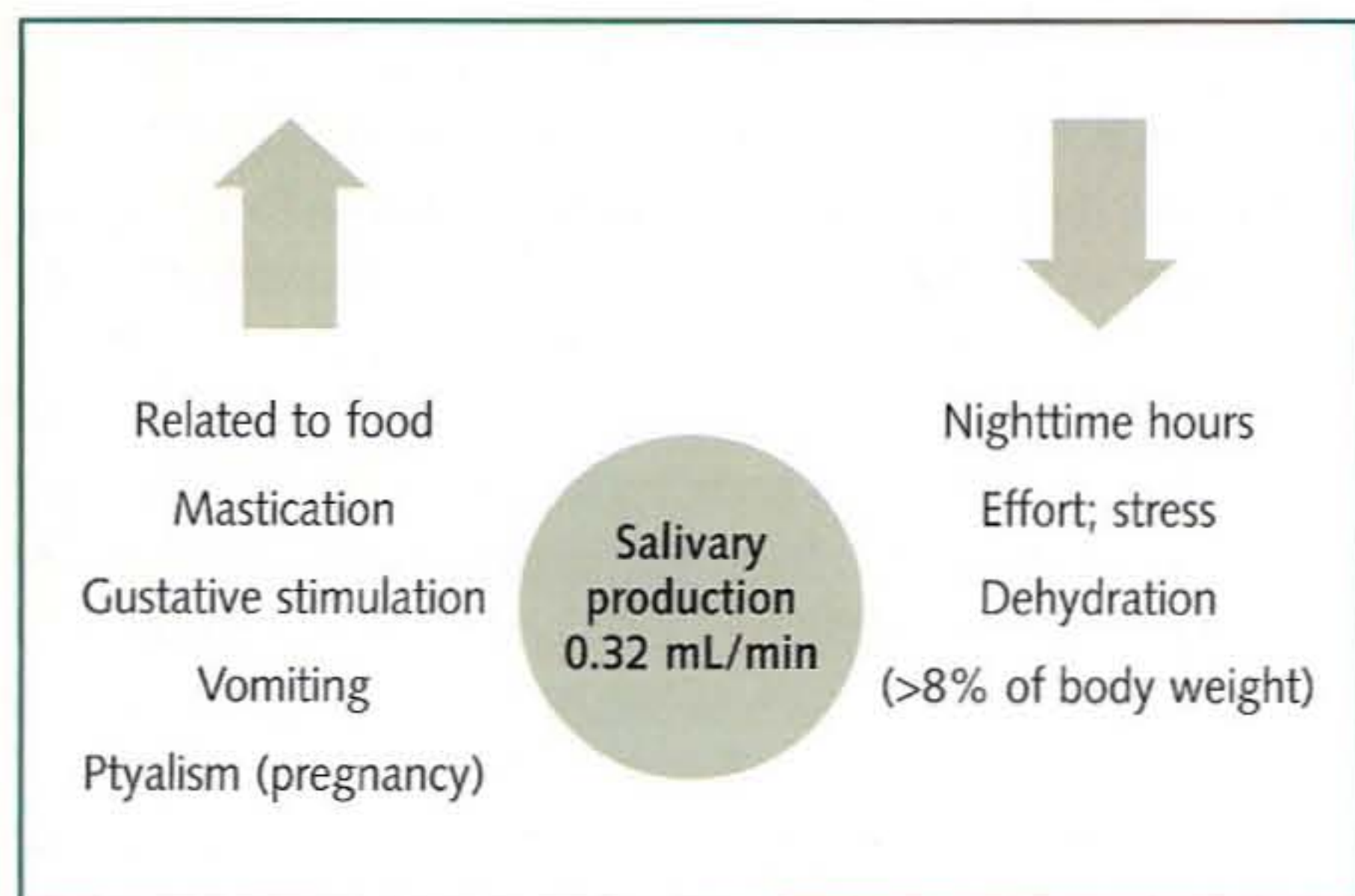


Fig 5-5 Physiologic variations of salivary volume.

The antibacterial factors originating from the glands are important. These nonimmune salivary proteins represent a key component of the host's defense system, and some of these are multifunctional, thanks to the presence of surface receptors that perform different activities (eg, bactericidal and fungicidal).^{18,19} One of these is lysozyme, an antimicrobial protein whose antibacterial action depends on muramidase, a hydrolytic enzyme that destroys bacteria by attacking the peripheral membrane. Its damaging action differs depending on the species on which it is acting: Some strains, such as *Micrococcus lysodeikticus*, are rapidly destroyed, while others are resistant. The action of lysozyme is synergic to that of IgA, with effects that are bacteriostatic rather than bactericidal. Although lysozyme cannot perform any specific activity in relation to the cariogenic microorganisms, it is able to influence the ecological balance of the oral flora.

Another glycoprotein that has important bacteriostatic action is lactoferrin. This acts by linking iron ions and interfering with the metabolism of a large number of fungal and bacterial iron-dependent species, among which is *S mutans*.

The enzymes of the peroxidase-myeloperoxidase system, actively involved in the defense mechanisms of the oral cavity, are produced from the acinar cells of the major salivary glands; myeloperoxidase is also produced by leukocytes, which penetrate the oral cavity through the mucus and the sulcus of the gingivae. These catalyze the oxidization of thiocyanate to hypothiocyanate, an active antibacterial factor able to react with the sulfhydryl groups of microbial enzymes, transport carriers, or other proteins. The main function of the lactoperoxidase system is to block metabolism and inhibit the growth of bacteria and fungi.²⁰⁻²²

Other salivary factors are the histatins, basic proteins rich in histidine, which are only present in primates and in humans and have fungicidal, bactericidal, and bacteriostatic action. Histatins offer the first defense against candidosis of the oral cavity, and their reduced production constitutes one of the causes of increased susceptibility to fungal infections.²³⁻²⁵

Immunoglobulin M, IgG, IgA, and secretory IgA are the basis of the defenses specific to human saliva. Produced by localized plasma cells in the glands of the oral mucosa, secretory IgAs are antibody-specific proteins and differ from the secretory immunoglobulins because of the presence of an additional glycopeptide, called *secretion factor*, produced by the glandular epithelia. Secretory IgAs are the predominant immunoglobulins and include two subclasses: IgA1, which is the prevalent component, and IgA2. These constitute the principal immune defense mechanism present in saliva and play a very important role in the homeostasis of the oral microenvironments. Their presence is correlated to the bacterial colonization of the oral cavity; they are able to attach themselves to salivary film, and

they are also present in plaque. The IgAs have a short life, and, unlike IgG, they do not have an immunologic memory but work synergically with the other nonspecific immune defenses of the saliva. They are able to reduce bacterial adhesion to the mucosa and teeth and limit bacterial agglutination, in this way contributing toward the penetration of antigens in the structure of the mucosa, where serum antibodies are rarely effective.²⁶

Saliva has numerous and important functions that stem from both its organic and nonorganic components. The salivary secretions represent a complex agglomeration of molecular families that are endowed with biologic activity and with properties that give them unique characteristics of protection with regards to teeth and mucosa. The basic secretions have lubricating and hydrating functions on the epithelia, regulate the mechanisms of bacterial adhesion to the dental surfaces and restorations present in the oral cavity, and exert control over the growth of bacteria. The stimulated salivary flow allows for the formation of the food bolus, stimulates sensations of taste, and, with the cleansing action of the tongue, contributes to the continual removal of bacteria and food residue from the oral cavity (see Box 5-2).

In addition, saliva modulates the processes of demineralization and remineralization of the enamel, playing a fundamental role in the prevention of caries decay.^{2,27} Its capacity to neutralize the acids produced in the oral cavity is linked to three principal chemical systems: bicarbonates, phosphates, and proteins. Its buffering capacity arises from hormonal and metabolic influences beyond the general state of health and is usually greater in males. In women, it decreases distinctly during the last months of pregnancy to increase after the birth, is reduced during menopause, and increases with the introduction of hormone substitutes.

Hypofunction of the Salivary Glands

The most important causes of hypofunction of the salivary glands are systemic diseases (diabetes mellitus, rheumatoid arthritis, systemic lupus erythematosus, and infection with human immunodeficiency virus [HIV]), pharmaceutical drugs, and radiation treatment of the cervicofacial area.

Reduced salivary production can be defined with both the terms *xerostomia* and *hyposalivation*. With the former, the subjective sensation of a dry mouth is an indication; the latter is diagnosed when the unstimulated salivary flow is reduced to less than 0.12 mL/min (38% of the norm) and when the stimulated flow is less than 0.6 mL/min.^{28,29}

Hyposalivation is very difficult to diagnose accurately, because the salivary flow is influenced by numerous factors, such as drinking, eating, smoking, and general oral hygiene

management. Such activities should be suspended for at least 1 to 2 hours before a saliva sample is taken.

The prevalence of xerostomia varies between 10% and 80% of subjects; the extreme variability of the data is linked to the way in which the questions regarding “dry mouth” are formulated: “Does it happen sometimes?,” “Does it happen often?,” or “Do you always have a dry mouth?”^{30,31} The symptom occurs when the salivary flow is halved, and the principal cause of its occurrence is pharmaceutical drugs. A close relationship between this effect and the number of medicines taken has been noticed,³² and there is a hypothesis that xerostomia has a close relationship with diseases for which certain medicines are prescribed. Certain drugs therefore have a side effect of increasing the symptoms.³³

The etiology of hyposalivation is similar to that of xerostomia: above all, systemic diseases and certain medicines. The extent to which age plays a part is still controversial, often because studies involving elderly subjects are influenced by the coexistence of various diseases; indeed, significant reductions of the salivary flow has not been observed in healthy older people.³⁴

Therapies that are extremely prolonged can have damaging effects on the salivary glands. The prolonged reduction of the salivary flow encourages the accumulation of medicines in the cells until a toxic endocellular concentration is reached. In time, organic damage from progressive destruction of the very fragile acinar cells, which are very sensitive to physical and chemical aggression, can follow from a purely functional block of secretion.

There are essentially three causes of salivary hypofunction³³ (Box 5-3): dehydration, damaged salivary glands, and reduced neurologic stimulus for salivary secretion.

The clinical effects of xerostomia are well known.³⁵ It is rare that xerostomia is an isolated symptom. The absence of saliva, in relation to the multiple functions that it carries out, brings about a complex and articulated set of symptoms. The patient often complains of an increase in time spent chewing, difficulty with phonation, dysphagia, and, in more advanced phases,odynophagia, alteration of taste perception, and the onset of paresthesia and glossodynia. The continuation of the clinical conditions eventually results in inflammation and atrophy of the oral mucosa and the occasional appearance of ulcers. The major or minor damage to the self-cleaning mechanisms is responsible for the increase in local irritating factors. In addition, in the first 3 months, clear alterations in the bacterial load and the composition of the plaque occur, with large increases in *S mutans*, lactobacilli, actinomycetes, and staphylococci. This consequent change in the bacterial flora and local decrease in pH, linked to the decrease in buffering by saliva, favors the growth of acidophilic fungi (especially *Candida albicans*) and an increase in risk of caries.³⁶⁻³⁸

Box 5-3 Factors that reduce salivary flow

Dehydration

- Reduced consumption or increased loss of liquids (sweating, vomiting, diarrhea, polyuria, hemorrhage, and systemic low-protein concentration)

Damage to salivary glands

- Irradiation of head and neck
- Autoimmune diseases (Sjögren syndrome)
- HIV
- Drugs (bethanidine, bretylium, clonidine, guanethidine, iodides, phenylbutazone)

Interference with neurologic stimuli

- Drugs/medication
- Anticholinergic drugs
- Antidepressant and psychoactive drugs: imipramine, amitriptyline
- Antihypertensive drugs: clonidine, methyldopa
- Antihistamines: brompheniramine, diphenhydramine
- Sedative and hypnotic drugs: diazepam, tamazepam
- Analgesic drugs: propoxyphene
- Others: antiemetic and antiparkinsonian drugs

Interaction Between Saliva and Dental Materials

Besides being well-tolerated by the body, any substance introduced in the oral cavity should ideally have good stability in the salivary environment and should not provoke corrosion.³⁹⁻⁴² *Corrosion* is defined as a chemical reaction between a metal and the surrounding atmosphere, resulting in the formation of metallic compounds that are chemically more stable than the original metals. Corrosion is a highly undesirable phenomenon. It ruins the esthetics of a material and can compromise its strength. Unfortunately, corrosion is common. The moisture of the oral cavity, the variations of temperature, the variations of pH according to the type of diet, and the decomposition of food encourage its onset.

Saliva is an excellent electrolyte, and, in its presence, the alloys used for rehabilitation cause the development of electric potential differences, giving rise to the phenomenon of oral galvanism. Besides causing pain, oral galvanism can cause ulcers of the mucosa and tarnishing and corrosion of metallic restorations. Electrolytic corrosion is caused by an electrochemical reaction (electrolysis and electrogalvanic currents). This can occur in three circumstances: contact between materials of different composition, differences of electrolytic composition, and conditions of stress to which the metal is exposed.



Fig 5-6 Areas of corrosion are evident around the soldering between the bar and the healing caps with marked zones of gingival recession.



Fig 5-7 Corrosion is linked to a lack of oral hygiene, a poorly finished prosthesis, and the accumulation of tartar.

An example of the first circumstance is areas of corrosion that are created at the interface of two differing metallic repairs (eg, a gold inlay and an amalgam restoration) or those which can be found when an orthodontic bracket or prosthesis is present because of the different composition of the soldering material and the alloys in the appliance (Fig 5-6). A metal or an alloy can face corrosion in the presence of a different concentration of electrolytes. For example, the electrolytic composition of a metallic restoration partially covered with food residue differs from that of the saliva, and this can contribute to the corrosion of the restoration itself. In the case of metallic restorations that are not correctly polished, the surface concavities can quickly fill with food residue, resulting in a rapid decrease in the concentration of oxygen, which can cause consequent corrosion and porousness of the metal or alloy in question (Fig 5-7).

Another negative condition is caused by the coexistence of corrosion and mechanical overburden or stress. Indeed, in these conditions, the initial corrosive cracks can intensify enough to cause a complete break in the metal or alloy.

The most relevant clinical consequence of electrolytic corrosion is galvanic pain: Intermittent contacts between metallic restorations of different materials allow the creation of an electrical circuit that causes painful stimulation of the nerve endings in the dental pulp. As time passes, the pain lessens, thanks to the development of protective mechanisms that neutralize galvanism: polarization and cataphoresis. Polarization consists of an accumulation of hydrogen at the negative pole that impedes the generation of electricity; cataphoresis is the transportation of colloidal particles toward the positive electrode in an electrical field. In both cases, the electrodes are isolated, thus creating interruptions in the electrical circuit. The effect of polarization on pain is very rapid, but it stops with the disappearance of the hydrogen ions secondary to the interruption of the electrical cir-

cuit. For this reason, after some time, pain may reoccur. Cataphoresis, on the other hand, takes longer to establish but is more effective, because the protective colloidal film can only be removed with mechanical action.

The prevention of corrosive phenomena can be achieved with certain precautions. Above all, noble alloys (gold, platinum, palladium, etc) and passive alloys (chrome or titanium) should be used whenever possible.⁴³ A metal is defined as electrochemically passive when it is able to form stable oxides in the presence of an electrolyte. It is also necessary to avoid, as far as possible, the coexistence of differing metallic restorations. All artificial prostheses must be fabricated according to the correct laboratory procedure and must be accurately polished.

Biocompatibility of Dental Materials for Prosthetic Use

There are two questions that must be asked when the clinician chooses prosthetic materials: What effect do they have on the oral environment and at what level and to what degree are they modified by the oral environment? Any substance inserted in the oral cavity should be well tolerated without causing toxic effects on the patient, on the dentist, or on whoever is manipulating it (eg, hospital staff, dental technicians). Furthermore, it should not irritate the intraoral and extraoral tissues, cause allergic reactions or genetic mutations, or be carcinogenic. Contact between tissues and materials can generate a wide range of reactions, from complete tolerance to an intense inflammatory reaction. The extent and the type of reaction depend on the composition of the materials, on their surface characteristics, and on the way prostheses are created.

All metals used in the oral cavity are subject to corrosion and consequent freeing of ions, the true intermediaries of the clinical and cellular consequences. Data found in the literature^{44,45} are chiefly concerned with the cellular reactions to the principal nonnoble metal components (beryllium, nickel, molybdenum, and chromium) common in the alloys used in prostheses. All these ions can provoke metabolic and structural changes (eg, cellular shortening, reduction of mitochondria, detachment of polyribosomes, accumulation of lipid drops), while still maintaining an unaltered morphology. Thus, the usefulness of morphologic studies is limited because of the varying differences that exist between metabolic alterations and cellular stress, whereas study of biochemical alterations has been shown to be much more reliable, especially in the early phases. For this reason, the cytologic studies that are today considered most valid are those that are biochemical, not morphologic.⁴⁶

Among the metals contained in alloys of common prosthetic use, nickel and chrome should be particularly mentioned because of their allergy-causing and potentially cytotoxic properties.⁴⁷ Fortunately, the intraoral tissues are very resistant to sensitization, to such a degree that cases of certified sensitivity are not common; however, a certain percentage of patients will be allergic.

Sensitivity to nickel varies from between 0.8% to 20.7% in males and between 9.0% and 31.9% in females. This difference is linked not to gender but to a greater frequency of body contact with the metal (jewels, piercings, etc). Sensitivity to chrome is 1.5% in men and 4.0% in women. Recent research has shown how certain alloys do not behave in an absolutely passive way when exposed to the oral environment. Patients with bruxism seem especially able to free a greater quantity of ions in the oral environment and in the alimentary canal.⁴⁷ One study⁴⁸ reported that the presence of nickel and metallic chrome in food makes the immune systems of laboratory guinea pigs more tolerant to both metals. Even if these data are indicative, this finding still has not been repeated in vivo, where the problem of sensitivity to metals is more complex.

Before any type of restoration of the oral cavity is undertaken⁴⁷:

- An accurate patient history should be completed, to investigate the risks of the eventual onset of allergies.
- To avoid sensitization, the patient should not be subjected to routine allergy tests (patch tests).
- All patients who might be sensitive to metals should be sent to a dermatologist for consultation.
- Alloys containing nickel should be avoided in patients with a known sensitivity to this metal.

Furthermore, in medical literature, nickel and chrome are considered elements with potential cytotoxicity.^{49–53} Their capacity

to initiate the onset of carcinoma in animals is well documented. In humans, the recorded cases are sporadic, and the interpretation of epidemiologic studies is difficult, especially as far as the onset of lung tumors is concerned.⁴⁷ Primary carcinoma has been found in patients who have undergone rehabilitation with implants, and, in some cases, tumor lesions have been found near prosthetic restorations undertaken with alloys that contain nickel and chrome. The patient, therefore, should always be informed of the potential risks (tumors and allergies) linked to the use of these metals and of the possibility of the use of alternative materials (noble alloys, for example).⁵⁴ Each patient should always sign a document giving consent for the use of these materials before being subjected to rehabilitation treatment of any type.

Nickel and chrome also carry a potential risk for the dentist and the dental technician. They are subjected to processing that frees microparticles that are easily inhaled and can cause an increased risk of lung tumors. Work conditions are therefore extremely important; a mask should always be worn to avoid inhalation of the potentially carcinogenic microparticles, and work should always be carried out under aspiration, at high speed, and in a ventilated environment.

Relationship Between the Oral Ecosystem and the Durability of the Prosthesis

Interaction among artificial prostheses, soft tissues, and salivary secretions determines the success or failure of treatment.

Many components of the salivary fluid, such as mucin, albumin, fibronectin, and IgA, have the ability to selectively bond with microorganisms. This suggests their direct involvement in the process of bacterial attachment to natural teeth and to the surface of the prosthetic restorations.^{12,13} For this reason, in every prosthesis, the choice of materials should always be directed, where possible, toward those that retain less plaque on their surface, to avoid, over time, negative repercussions on the health of the dental tissues, periodontium, and mucosa.^{55–58} Knowledge of the chemical and physical characteristics of the materials used in prostheses and the way in which artificial prostheses are manufactured and polished is of significant relevance. Among the most common materials, porcelain and resin merit particular attention.

The indications for use of porcelain are numerous: It is used for artificial teeth in removable prostheses, for construction of metal-ceramic crowns and inlays, and for veneers in metallic and nonmetallic restorations. Its low level of electrical conductivity, stability in the oral cavity, and esthetic qualities are its

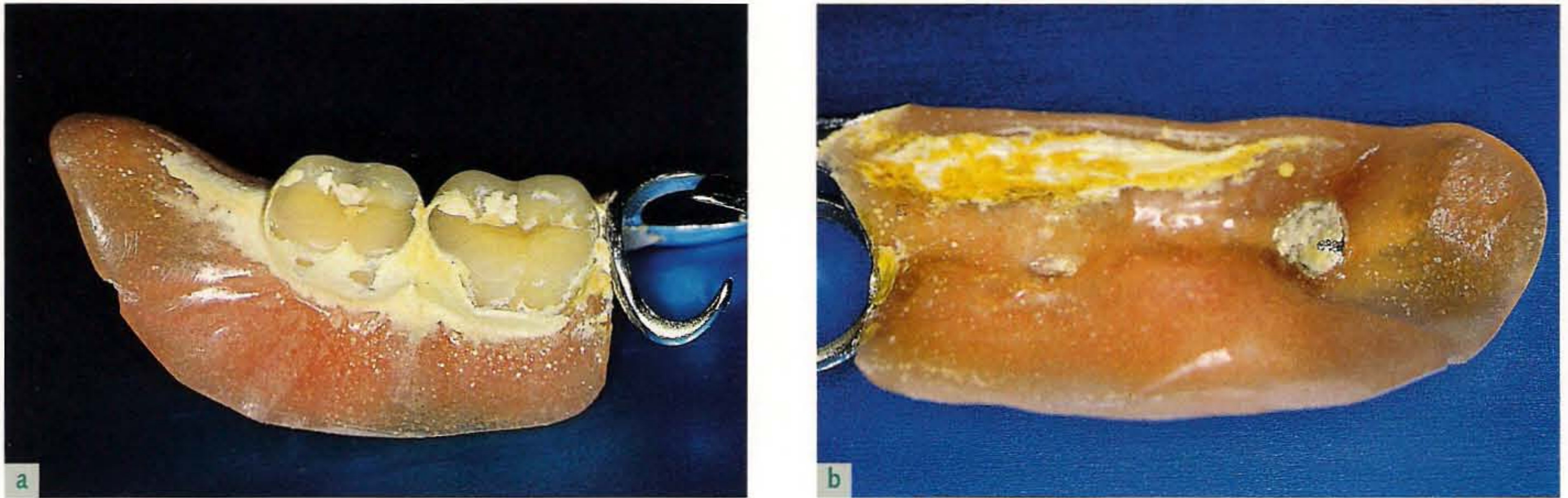


Fig 5-8 The accumulation of tartar (a) around the denture and (b) on the prosthetic base is clearly evident.

strongest advantages.⁵⁹ Among its disadvantages is the onset of porousness, caused by volumetric contractions (30% to 40%) following the loss of water during laboratory baking. Increased plaque retention, increased fragility, and compromised esthetics due to the reduction of shine are the inevitable consequences. To avoid these problems, it is advisable to adopt two precautions: The ceramic should be heated in a vacuum to eliminate air bubbles and cooled under pressure to reduce the dimensions of the pores.

In patients who have metal-ceramic or gold-resin restorations and who need topical fluoride prophylaxis, the fluoride solution should be prepared at neutral pH. Indeed, the hypothesis has been advanced that acidic fluoride products (eg, acidulated sodium fluoride) can damage such manufactured articles because fluorotic acid is often used for long periods in laboratory procedure to remove the ceramic component from a metal-ceramic prosthesis for correction or polishing. Considering, however, that only the cumulative effects of such compounds are to be avoided and that the low pH seems more damaging with respect to the degree of concentration of fluoride, their substitution with fluoride preparations at neutral pH appears sufficient to prevent undesired effects.⁶⁰⁻⁶¹

Acrylic resins are also common for prostheses.⁶¹ These are not toxic for the organism or the oral tissues and, if manipulated correctly, do not cause irritation. They have good esthetic properties and are of a low electrical conductivity. They are insoluble and inert when in contact with oral fluids but have a certain tendency to absorb water, resulting in undesirable variations in dimension. The mechanical properties of acrylic resins are not ideal because the surface may become porous during polymerization and resistance to abrasion is low; on the other hand, they are easy to repair and restore. Correct laboratory procedures are essential in order to limit defects. Baking at temperatures that are too low can cause the release of monomers



Fig 5-9 Decubitus lesion. The reduced local tropism and keratinization of the epithelia linked to aging favor the appearance of lesions that entail a long and difficult healing process.

from the prosthetic base; these monomers can irritate the mucosa. Free monomers act as plastic elements, increasing the flexibility and the fragility of the resin. Defects in polymerization can cause porosity, resulting in increased plaque retention and inflamed tissues.⁶²

It is essential to polish all prostheses well: Food deposits on rough surfaces are difficult to remove, regardless of how well oral hygiene procedures are performed, and the products of decomposition can cause corrosion of metallic restorations. Furthermore, rough surfaces are not tolerated as well by patients⁵⁷ and can encourage the accumulation of plaque and tartar (Fig 5-8).

In patients who are partially or completely edentulous, the success of rehabilitation depends on factors both of mechanical retention and a physical nature, which are more closely related to the characteristics of the oral cavity. The retentive property



Fig 5-10 In fixed prostheses, (a) management of interproximal spaces is very important, together with (b) the shape and the arrangement of the artificial teeth and (c) the positioning and precision of the margins.



Fig 5-11 Areas of corrosion are linked to extremely poor oral hygiene, a lack of management of the interproximal spaces, and deficient shaping and finishing of the margins of the prosthesis.

of complete prostheses^{63,64} is linked to the presence of salivary biofilm. The forces of attraction that exist between oral mucosa and acrylic resin depend on the presence of a uniform (salivary) film on the surface of the denture bases. This creates a difference in pressure with respect to the external atmosphere that stabilizes the prosthesis. Usually, the lubricating and hydrating action of the salivary film that forms between the prosthesis and the mucosa works to protect the tissues from the pressures caused by chewing and reduces local friction to a minimum.

In addition, the epithelium of the oral cavity constitutes an important defense mechanism. It works as a physical barrier that is able to stop the colonization of transitory microorganisms, thereby contributing to maintenance of the equilibrium of the oral bacteria. The continual exfoliation of the epithelial cells and the elimination of the microorganisms attached to them also contributes decisively to the control of bacteria.

In patients affected by hyposalivation, the reduction of the salivary biofilm compromises the stability of the denture bases, increasing patients' intolerance of the prostheses. Furthermore, the insertion of a removable prosthesis can cause the composition of the oral microflora to vary, with changes toward spiral-shaped pathogens, even if oral hygiene is appropriate.^{65,66}

Deficiency in lubrication and hydration of the mucosa increases the accumulation of food residue, increasing local irritation. The weakening of defense mechanisms because of the reduced local tropism of epithelia and the progressively diminishing keratinization of the oral mucosa encourage the development of decubitus lesions, which heal with difficulty and only over a long period of time, especially in elderly people⁶⁷ (Fig 5-9). The final result is the onset of ulcers, glossodynia, paresthesia, and pain.

Good design and planning of the prostheses also contribute greatly to the maintenance of the health of the teeth and the oral tissues. In a fixed prosthesis, particular attention must be given to the positioning and precision of the margins, to the shape and adjustment of the replacement teeth, and to the interproximal spacing so that the patient is able to maintain adequate oral hygiene⁶⁸⁻⁷¹ (Figs 5-10 and 5-11). In a removable prosthesis, the pressure created by chewing on the residual structures, the periodontium, and supporting tissues must be taken into account.⁷²⁻⁷⁷ Guidelines to providing a prosthesis that will help to maintain a healthy oral environment are given in Box 5-4.

Box 5-4 Guidelines for optimal prosthetic treatment

An accurate and detailed history:

- Allergies and medicines
- Food allergies
- Seasonal allergies
- Dermatologic conditions
- Allergies to metals
- Work activity
- Any dental implants
- Possible visits to medical consultants (dermatologist, oral pathologist, allergist)
- Possible patch tests for components of dental materials
- Informed consent from the patient
- Precise records of the characteristics of the materials used for the patient
- Correct choice of dental materials (noble and passive alloys)
- Correct clinical use of materials
- Correct laboratory procedures
- Correct finishing of prostheses

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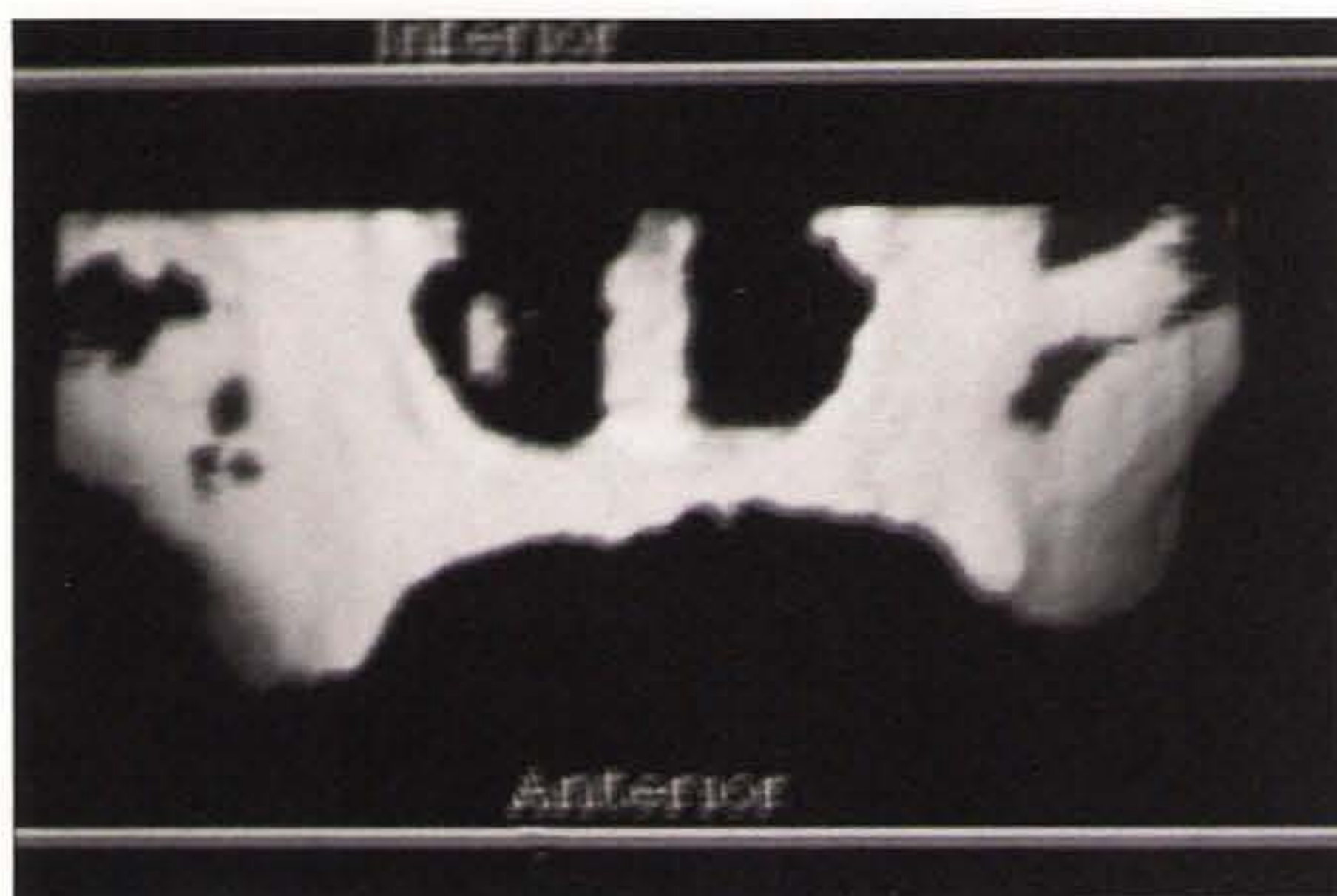


Fig 9-182 Three-dimensional CT revealing serious bone resorption in the maxillary incisive bone.

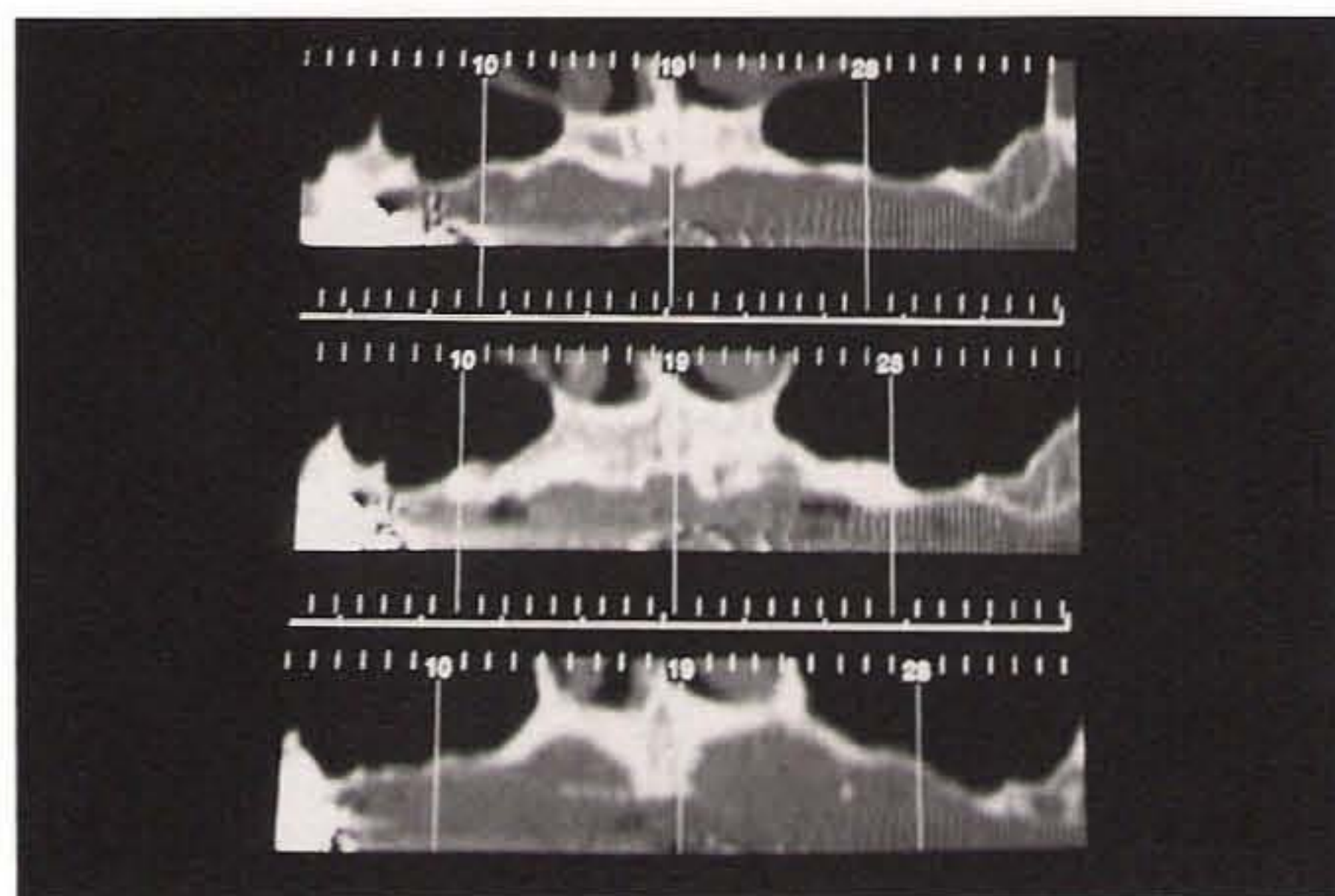


Fig 9-183 The CT scan indicates that atrophy is also extensive in the distal area of the maxilla.



Fig 9-184 (a to c) The bone graft taken from the iliac crest is prepared and adapted on a simulation model of the maxilla, made with the help of the CT.

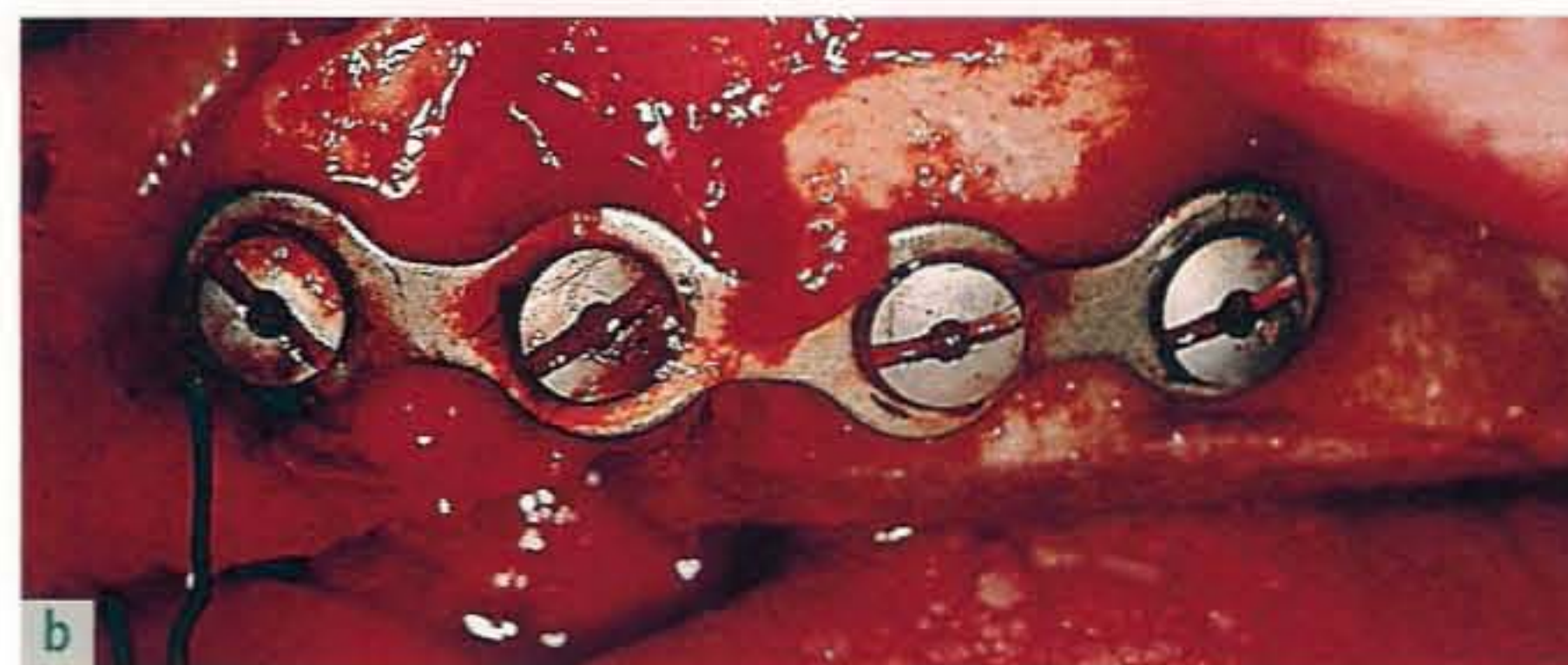


Fig 9-185 (a and b) The onlay bone block graft is fixed to the bone with an osteosynthesis plate.

Onlay bone grafting of the alveolar crest

In cases of diffused atrophy of the alveolar crest, extraction of a graft from the iliac crest is indispensable. The graft is shaped into a horseshoe¹⁹⁴ or a rectangular form¹⁹⁵ and rigidly anchored to the alveolar crest by means of implants placed simultaneously. With this technique, Nystrom et al¹⁹⁴ obtained an implant success rate of 74.4%. Other long-term studies, based on similar techniques, have shown a survival rate of 75%

after 5 years.^{196,197} The placement of the implants after healing of the graft (two-stage technique) increases the implant success rate while, however, doubling the healing period¹⁹⁸ (Figs 9-182 to 9-188).

The most frequent complications, found in 30% of cases, are dehiscence of the bone through soft tissues¹⁹⁷ and bone resorption during healing, equal to 30% to 40% of the initial volume.¹⁹⁹ Despite these limitations, the onlay technique is still considered reliable and is recommended for increasing the ver-

6

Periodontal Considerations

Proper prosthetic restoration presupposes a healthy periodontium, and, in turn, correct prosthetic rehabilitation is a prerequisite for maintaining periodontal health. This chapter does not aim to replace the more detailed treatises concerned with periodontics but is intended to provide the essential information necessary for accurate evaluation of the health of the periodontium and to enable a nonspecialist to undertake basic periodontal therapy. The etiology and pathologic processes of periodontal diseases and their classification are discussed in this chapter, as well as nonsurgical therapy and some surgical techniques that are undertaken to improve the condition of the periodontium prior to prosthetic restoration.

Etiology and Pathogenesis of Periodontal Diseases

The term *periodontal diseases* includes all pathologic conditions affecting the periodontium, traditionally divided into *gingivitis*

and *periodontitis*. Gingivitis¹ is an inflammatory condition of the marginal periodontium, conditioned by local and systemic factors, and essentially an expression of the inflammatory and immunologic reaction to plaque microbes (Fig 6-1).

Periodontitis¹ represents the further development of gingivitis and is characterized by the destruction of the deep periodontium (root cementum, periodontal ligaments, and alveolar bone) and soft tissues (Fig 6-2).

Gingivitis can be subdivided into three phases on the basis of the histopathologic sequence of events that occur due to the action of the bacterial plaque: initial phase, early phase, and established phase.² Clinically, gingivitis brings about reddening, edema, and bleeding³ and is aggravated by factors such as smoking, some medicines (eg, nifedipine, cyclosporine, and phenytoin), systemic diseases (diabetes), and hormonal changes.²

Periodontitis represents the evolution of established gingivitis and is characterized by an apical migration of the junctional epithelium associated with the destruction of the connective tissue attachment and alveolar bone. Although it is true that all



Fig 6-1 Clinical appearance of gingivitis.



Fig 6-2 Chronic adult periodontitis. Serious loss of periodontal support is associated with clinical signs of inflammation and dental migration.

cases of periodontitis are preceded by gingivitis, not all cases of gingivitis necessarily develop into periodontitis.⁴ Furthermore, periodontitis does not necessarily affect all the teeth and is therefore considered to be both subject and site specific.⁴ Because it is not possible to predict the sites in which gingivitis will develop into periodontitis, prevention and treatment of all cases of gingivitis are necessary.⁵

Periodontal diseases can be divided into four nosographic categories based on the degree of destruction and the age of the patient: gingivitis, early-onset (prepubertal, juvenile, or rapidly progressive) periodontitis, adult periodontitis, and necrotizing ulcerative periodontitis.⁶

Chronic adult periodontitis affects a good part of the population (about 35% of adults in the United States).⁵ Of these, about 13% of adults older than 30 years exhibit severe cases of periodontitis and about 22% suffer from a moderate-to-severe form of the disease.⁷

Modern concepts concerning the epidemiology of periodontal diseases are influenced by studies that suggest that only some subjects suffer from periodontal disease and that only some sites in the subjects are affected.⁸ The progression of periodontal disease can be considered a continuous process with periods of exacerbation.^{9,10}

Pathology and histopathology of periodontal diseases

Gingival tissue that is clinically healthy has a histologic inflammatory infiltrate because of the constant presence of microbial plaque. Even in the healthiest gingiva, a lymphocytic infiltrate is found, comprising neutrophilic granulocytes, the primary function of which is to absorb the bacteria after they have migrated inside the tissue through the gingival sulcus. The neutrophils are attracted by peptic-type molecules with chemotactic characteristics released by bacteria. The bacteria, which damage the epithelial cells, induce the release of cytokines, which stimulate the chemotaxis of the neutrophils toward the crevicular sulcus.¹¹⁻¹⁴

The neutrophils at the crevicular level can phagocytize the bacteria, removing them from the gingival sulcus. In this phase, gingival inflammation is reversible if the bacterial plaque is removed.³ In the first phases of gingivitis, the clinical changes are very modest, but marked histopathologic changes take place.

Page and Schroeder¹⁵ developed a clinical and histopathologic classification of periodontal disease to define the phases of inflammatory periodontal changes: initial lesion (clinical health), early lesion (initial gingivitis), established lesion (chronic gingivitis), and advanced lesion (chronic periodontitis). The initial damage appears within 4 days of plaque accumulation. It is not

clinically visible³ and is characterized by an acute inflammatory reaction to the accumulation of plaque.¹⁵ The initial damage is localized in the regions of the gingival sulcus and includes a portion of the junctional epithelium and the more coronal portion of the connective tissue.

Histopathologically, there is dilation of the arterioles and venules of the dentogingival plexus. There is also an increase in the permeability of blood vessels. The greatest change consists of an increase in the flow of the crevicular fluid and in a migration of the neutrophilic granulocytes from the vascular plexus into the junctional epithelium and the gingival sulcus. The inflammatory infiltrate occupies between 5% and 10% of the supracrestal connective tissue; the loss of collagen is localized in the area of the inflammatory infiltrate. This space is occupied by fluid, serum proteins, and inflammatory cells (Fig 6-3).

After about 7 days of plaque accumulation, an inflammatory infiltrate of mononuclear leukocytes transforms the initial lesion into an early lesion. The vessels remain dilated but increase in number because of the opening of vessels that were previously inactive. Lymphocytes and macrophages are predominant at the peripheries of the damage, together with a few plasma cells. In this phase, the inflammatory infiltrate occupies about 15% of the gingival connective tissue, and the destruction of the collagen fibers reaches 60% to 70% of the infiltrated area. Inflammatory cells fill in the space left by the destroyed collagen fibers. Clinically, the inflammatory modifications are erythema and edema³ (Fig 6-4).

After 2 or 3 weeks of plaque accumulation, the early lesion evolves into an established lesion. Clinically, significant edema and reddening of the gingiva occur. Established gingivitis is characterized by a more extensively affected area and by a predominance of plasma cells and lymphocytes in the peripheries of the damaged area; macrophages and lymphocytes are found in the lamina propria of the gingival pocket. At the level of the sulcus and the junctional epithelium, the neutrophilic infiltrate predominates.¹⁵⁻¹⁷ The sulcular and junctional epithelia can proliferate and migrate to the underlying connective tissue. The deeper gingival sulcus and the frontal coronal portion of the junctional epithelium changes to an epithelial pocket. The epithelial pocket does not adhere to the dental surface and presents an increased leukocytic infiltration, with a predominance of neutrophils that migrate toward the epithelium (Fig 6-5).

Histopathologically, periodontitis is similar to established gingivitis but with a greater density of plasma cells. The evolution of gingivitis into periodontitis is certainly multifactorial. It depends on the individual and is impossible to foresee accurately. The changes to advanced damage include the formation of the periodontal pocket, ulceration of the epithelial surface, suppuration, destruction of the alveolar bone and the periodontal lig-

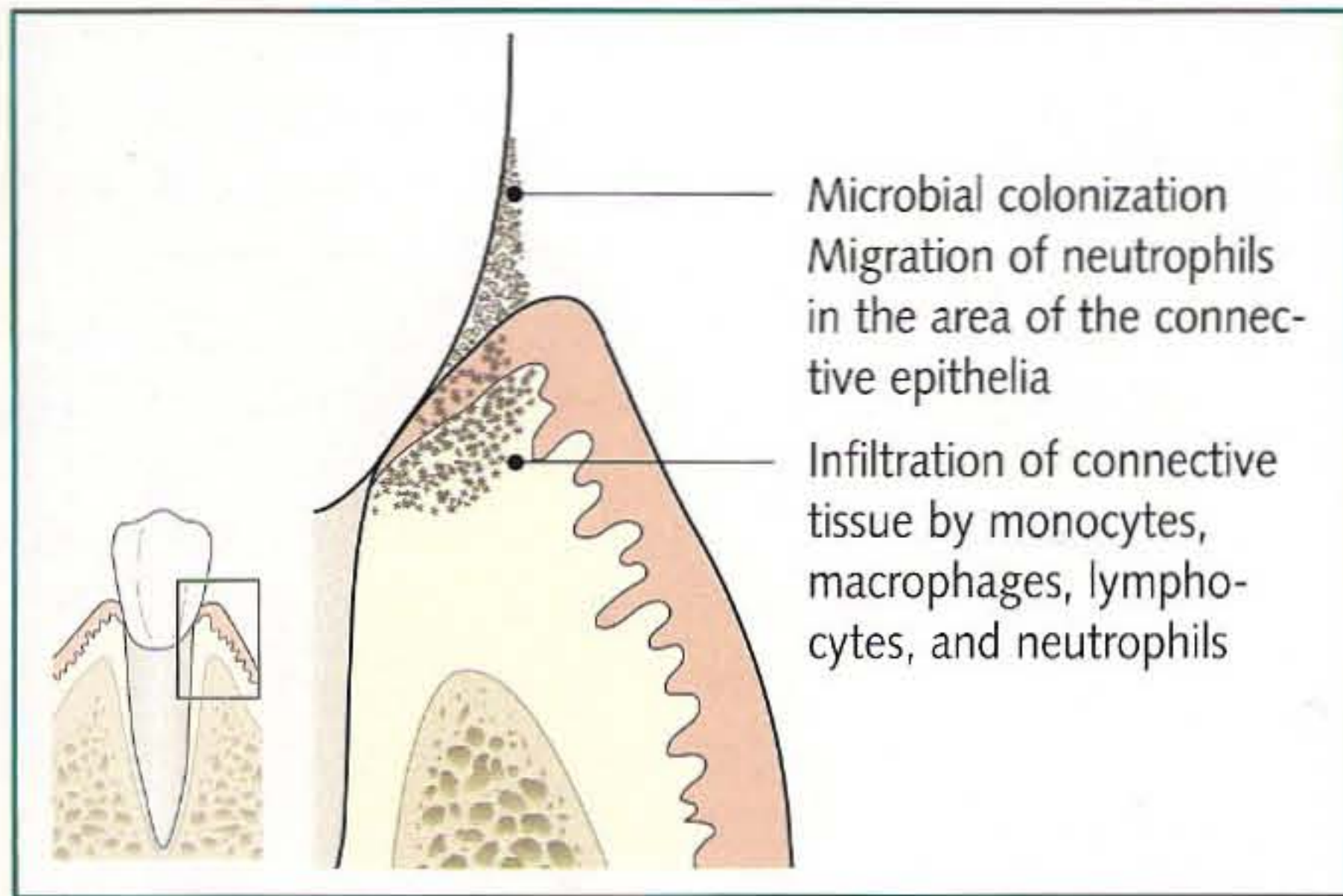


Fig 6-3 Initial lesion. Characterized by an increase in permeability of the blood vessels with increased leukocytic migration and perivascular collagen lysis. There is also initial alteration of the junctional epithelia.

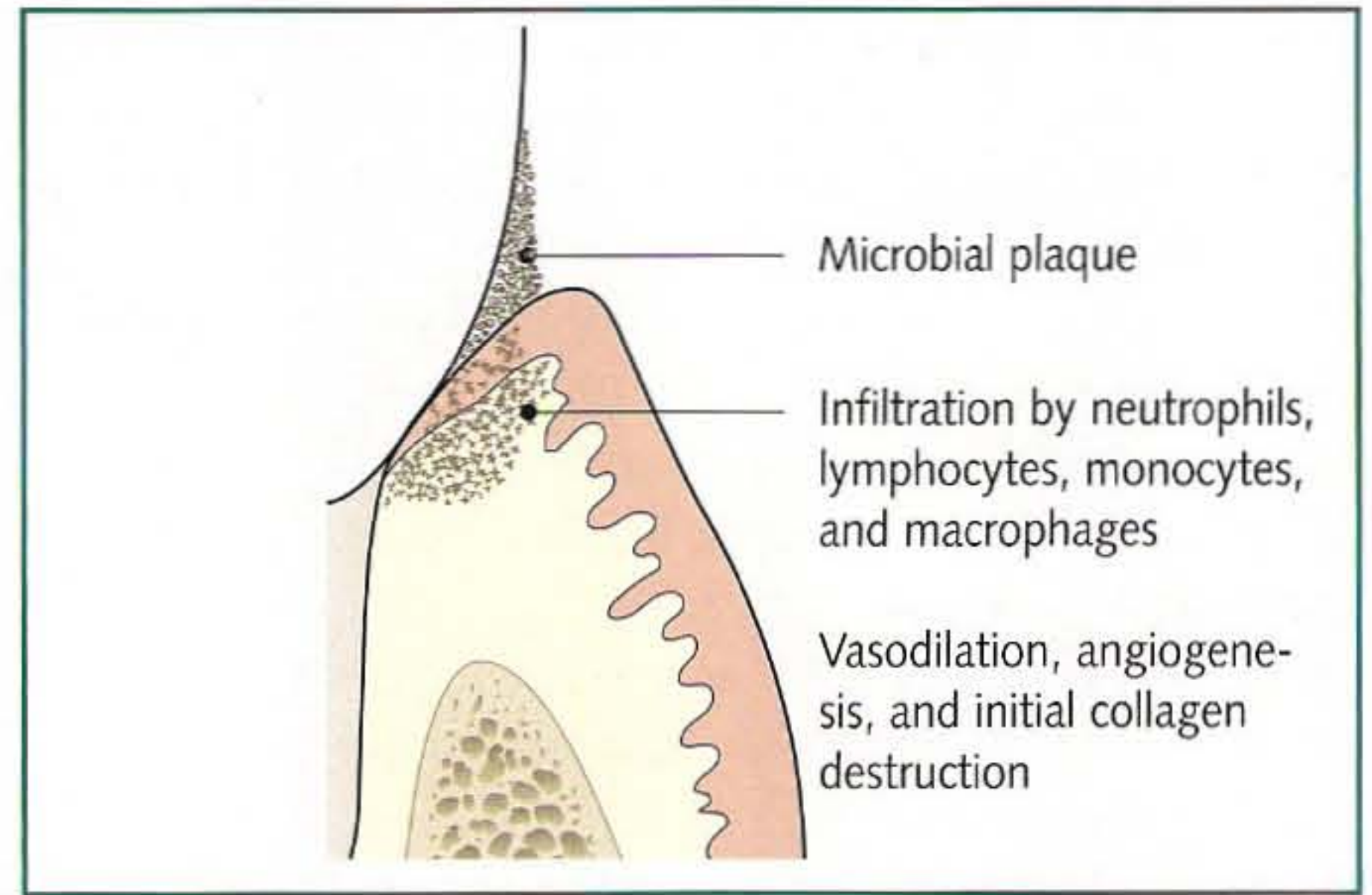


Fig 6-4 Early lesion. Characterized by the progression of the initial lesion associated with an accumulation of neutrophils and lymphocytes apical to the junctional epithelia. The loss of collagen fibers is limited to the marginal gingiva.

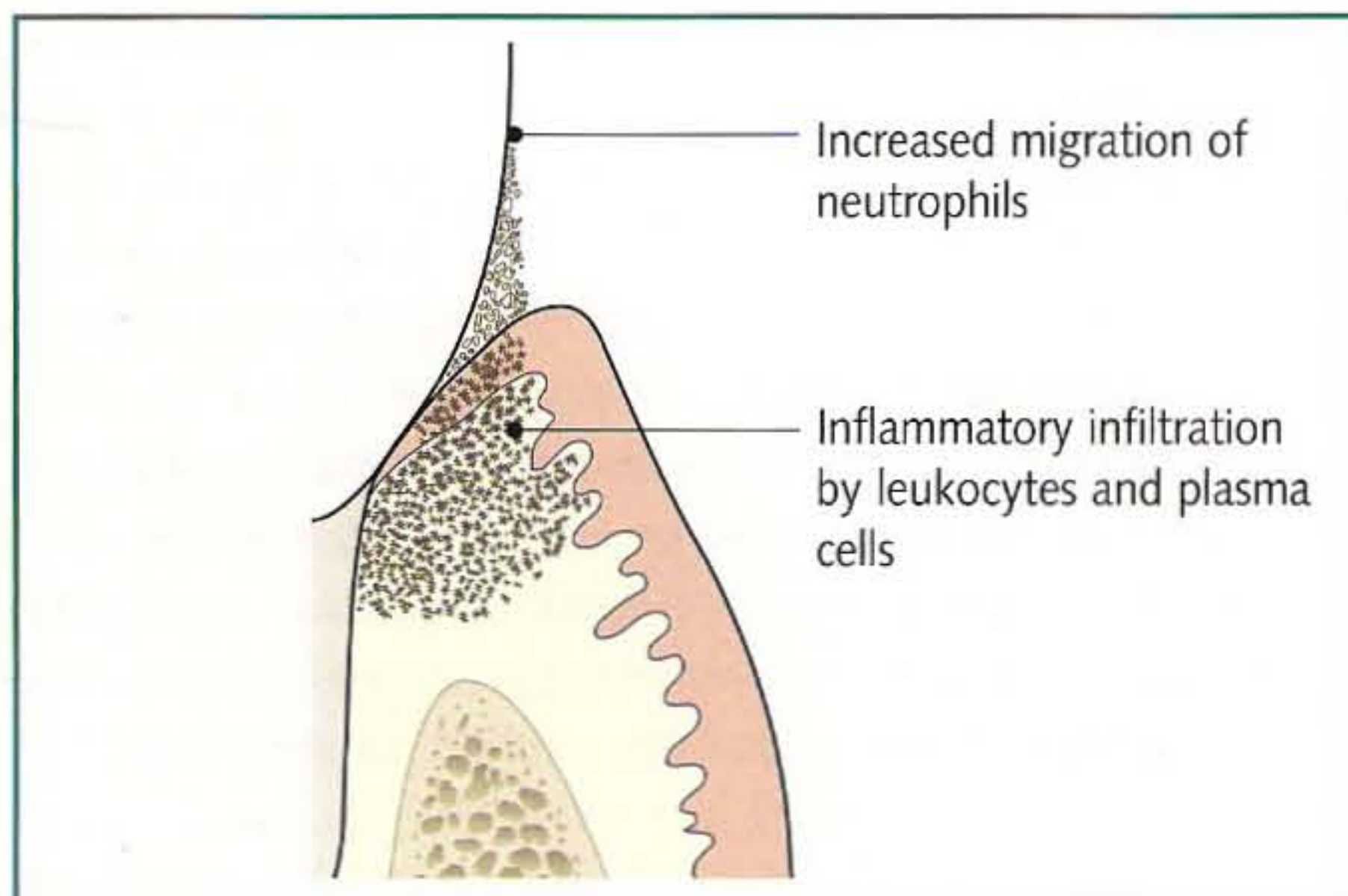


Fig 6-5 Established lesion (chronic gingivitis). Characterized by an increase of plasma cells in the gingival sulcus, the junctional epithelia, and the connective tissues. Apical migration of the junctional epithelia is associated with a later loss of collagen fibers and connective matrix. Pseudopockets appear because of the gingival edema.

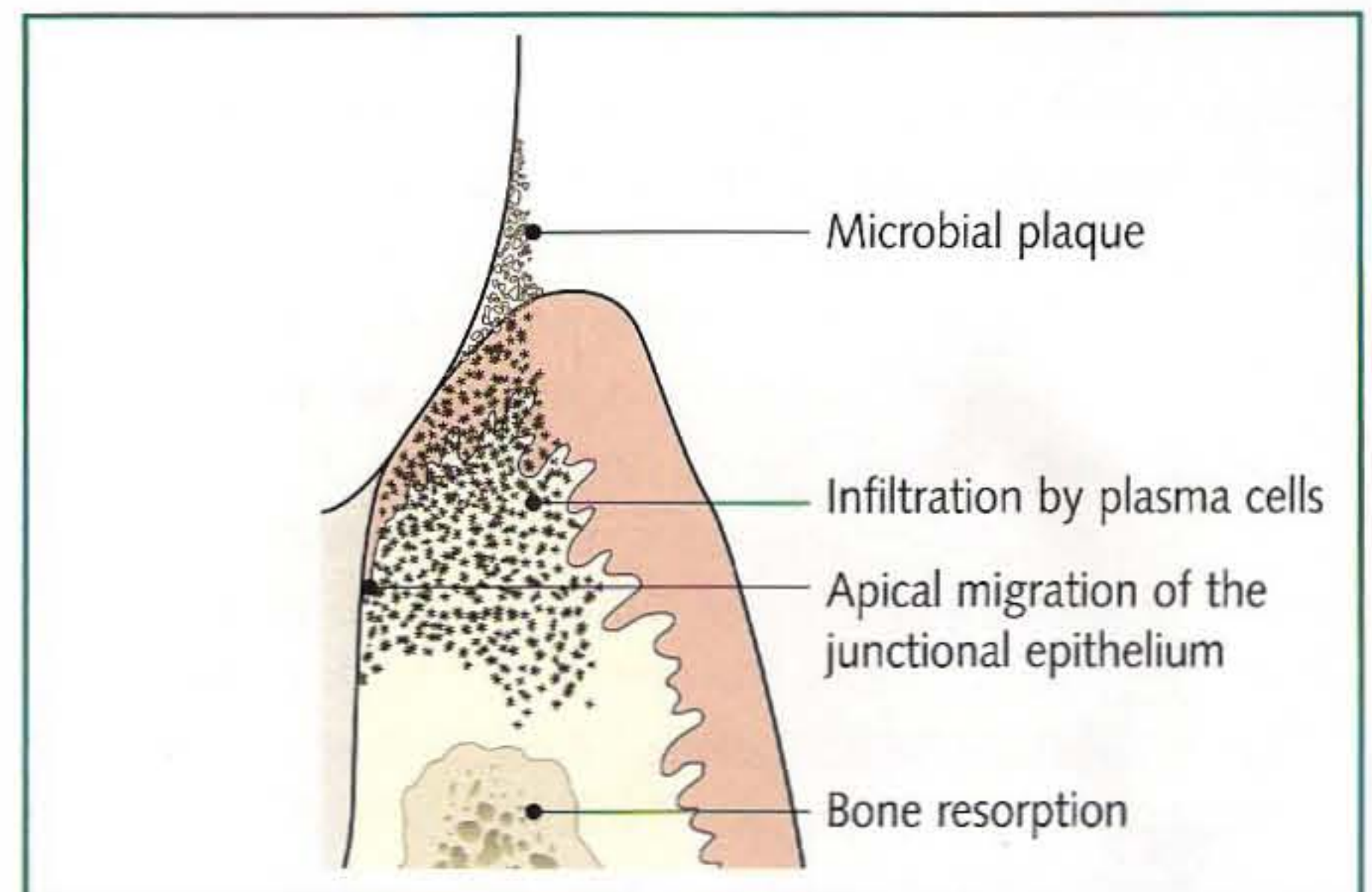


Fig 6-6 Advanced lesion (periodontitis). The established lesion evolves into an advanced lesion when the loss of collagen fibers and connective matrix extends to the periodontal ligament. The progression of the lesion to the alveolar bone and the periodontal ligament results in the formation of periodontal pockets.

aments, movement, and eventual loss of teeth. Advanced damage is characterized by the same histopathologic changes present in established gingivitis, but it is accompanied by the involvement and destruction of the connective tissue and apical migration of the epithelial attachment¹⁶ (Fig 6-6). The evolution of gingivitis into periodontitis is characterized by a predominance of T and B lymphocytes; today, however, it is accepted that the plasma cells are the cells that are the most abundant in advanced periodontal lesions.¹⁸

The tissue destruction that characterizes periodontal disease is the result of direct microbial action and immunologic reac-

tions.¹⁹⁻²² The presence of microorganisms that are considered to be potentially pathogenic for the periodontium appears to be necessary but not sufficient for the onset of the disease. Periodontitis is the consequence of the interaction of genetic, environmental, immunologic, and microbial factors. The presence of microorganisms is the crucial factor for the establishment of periodontal disease, but the development of the disease is related to the immunologic reaction of the individual and to certain risk factors. Some of the principal risk factors include age, gender, smoking, and some systemic diseases, such as diabetes mellitus.

Microbiology of periodontal disease

In the human subgingival microbial plaque, about 300 to 400 types of bacteria have been found; of these, 10 or 20 types can play a significant role in the pathogenesis of periodontal disease.²¹

The gingival sulcus area encourages microbial growth, but, to colonize the subgingival area, the microorganisms must overcome a certain number of immunologic barriers. These include nonspecific processes such as mechanical cleaning, salivary flow, and the flow of crevicular fluid. Some constituents of saliva and crevicular fluid help to prevent the colonization and adhesion of the bacterial cells to the dental and tissue surfaces. If the bacteria elude the prohibitive factors of the saliva and are able to attach themselves to the tissue surface of the subgingival area, other immunologic mechanisms intervene (epithelial exfoliation, antibodies, and phagocytes). When the bacteria reach the connective tissue, the B and T lymphocytes, neutrophilic granulocytes, and macrophages intervene.

Despite having identified the bacterial plaque as a primary etiologic factor of periodontal diseases, there are still discussions about the exact mechanisms that trigger the pathologic process. One theory maintains that there is not a specific type of plaque that causes periodontitis; rather, it is related to the total mass of microbial plaque, and, consequently, a reduction of this quantity would control the activity of the disease. According to the theory of specific plaque, however, periodontal disease is instead linked to specific bacterial products and species, and, consequently, the objective of treatment becomes the identification and elimination of these pathogenic agents.²³

The microorganisms that are involved in periodontal disease are gram-negative anaerobes, cocci, and, in large measure, spirochetes. The bacteria that are considered most responsible for the destructive periodontal damage are *Prevotella intermedia*, *Bacteroides forsythus*, *Actinobacillus actinomycetemcomitans*, and *Treponema denticola*.^{24–28}

Susceptibility to periodontal disease and risk factors

Periodontal disease is considered a multifactorial disease. Even if specific microorganisms are considered potentially pathogenic, their presence alone is not sufficient to bring about the disease. The development of the disease is also related to risk factors of the individual, which include age, smoking, genetic factors, and some systemic diseases.²⁹

The prevalence of periodontal disease increases with age.⁷ It is not clear, however, whether aging increases the susceptibility of the subject or whether the prevalence of the disease in elderly people depends on a cumulative effect during life.³⁰

A consistent and positive association between smoking and loss of periodontal attachment has been confirmed both by cross-sectional and longitudinal studies.^{31–37} The risk of developing periodontitis for an individual who uses tobacco products can be considered 2.5 to 7 times greater than that of an individual who does not use these products.³⁸ Even when the level of plaque accumulation and gingival inflammation are not significantly different, smokers show an increase in the prevalence and the severity of periodontitis. Smoking also can negatively impact the results of both surgical therapy³⁹ and nonsurgical therapy. The process through which smoking determines attachment loss has not yet been shown.⁴⁰

Systemic illnesses that depress the immune system defenses of the organism may increase the risk of periodontal illness. A reduction in the number or functionality of the neutrophils has been associated with severe periodontitis.⁴¹ It has been shown that diabetes mellitus increases the risk of periodontal disease.^{42–45} No significant differences in prevalence or severity of periodontal diseases between individuals with the human immunodeficiency virus and healthy individuals have been documented.^{46–48}

A good deal of evidence shows that genetic influence has a prominent role in periodontal disease.^{49,50} Convincing studies on twins have shown that a genetic factor predisposes individuals to periodontal disease^{50,51} and to severe forms of early-onset periodontitis. At the moment, researchers are focusing on identifying the genes that may be involved in various types of periodontitis. Recently, attention has been focused on genetic polymorphism of genes involved in the production of cytokines, which has been linked to an increased risk of periodontitis in adults.⁵²

Diagnosis

A correct diagnosis is achieved through the evaluation of data gathered through history, clinical periodontal examinations, radiographic evaluations, laboratory examinations, and, when necessary, consultation with specialists.

History

An accurate history must always precede the clinical analysis, because it represents the first phase of the diagnostic process. It should include reasons for the visit, symptoms, and medical and dental history. The reason that the patient has sought consultation should be noted and may be useful over the course of the treatment. Patients suffering from periodontal diseases, in the absence of acute episodes, usually do not complain of painful symptoms. In some cases, they can be so



Fig 6-7 Clinical appearance of healthy periodontal tissues.

accustomed to the symptoms of the disease that they do not even mention them. Indeed, in the majority of cases, it is the dentist who recognizes the disease. Patients with periodontal disease may report spontaneous bleeding or bleeding when brushing, movement of teeth, development of diastema, edema of the gingiva, and abscesses. It is important to know whether the patient is seeing a physician and is undertaking any therapies as well as whether the patient's general condition can influence the diagnosis or the periodontal treatment. Some of the conditions that may be relevant are heart diseases, rheumatic fever, congenital diseases, prosthetic valves, orthopedic prostheses, kidney or hepatic diseases, pregnancy, hypertension, diabetes, allergies, anomalous bleeding, infectious diseases, diseases of the blood or of the hemopoietic organs, and malignant tumors. Use of tobacco should also be noted.

It is the dentist's responsibility to obtain an accurate and complete medical history, and this job should not be delegated to anyone else. The dental history provides information regarding any previous dental therapies and contributes to the formulation of a correct diagnosis. The dentist should always obtain the patient's permission before recording the data. Detailed information about previous diagnosis and treatment can be extremely useful in the development of a periodontal treatment plan.

Clinical periodontal examination

The clinical periodontal examination consists of an inspection of the soft tissues, probing, and an evaluation of tooth mobility. A healthy gingiva, in the absence of melanin pigmentation, usually exhibits a coral pink color (Fig 6-7). Reddening is a clinical sign of gingival inflammation caused by an increase of vascularity and a reaction to local irritation produced by plaque and cal-



Fig 6-8 (a) Periodontal probing in the presence of abundant accumulated microbial plaque; (b) bleeding as a result of probing.

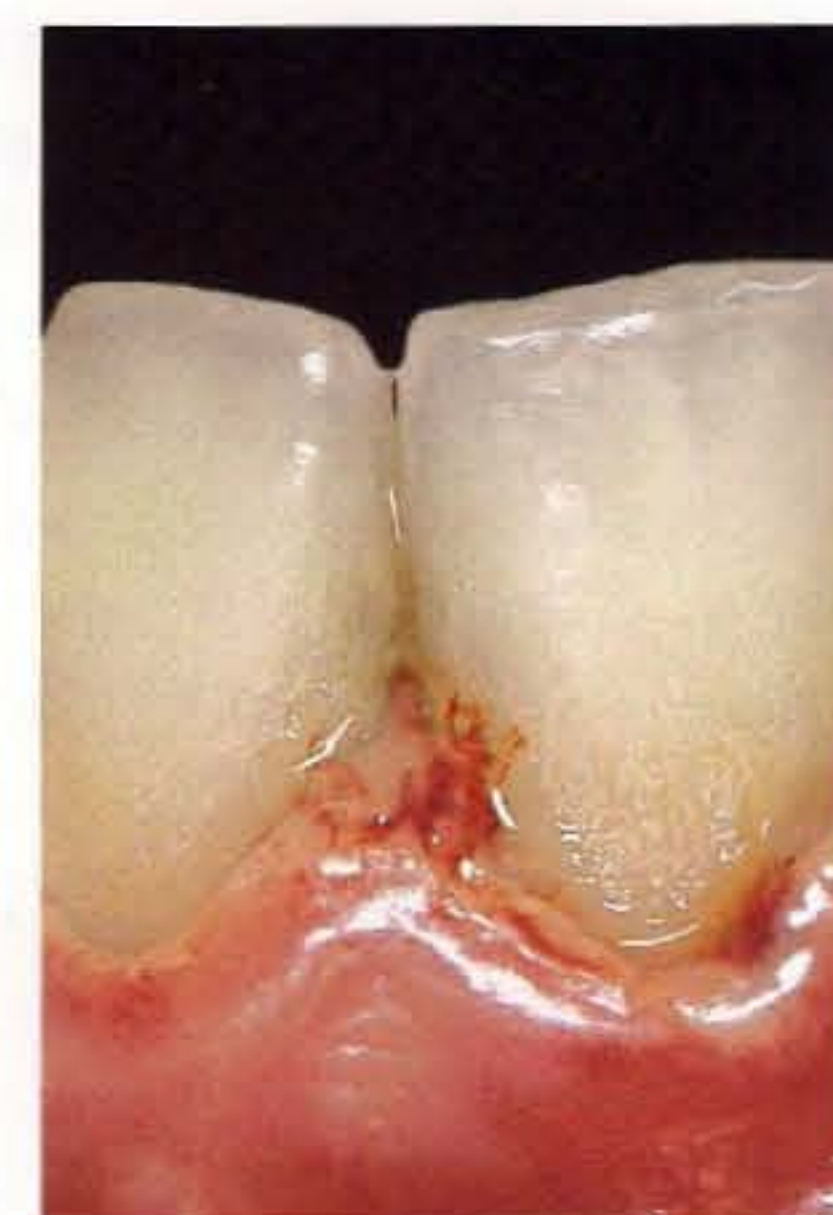


Fig 6-9 Necrotizing ulcerative gingivitis. Note the necrosis of the apical interdental papillae.

culus. Changes in the normal gingival scalloping in the absence of systemic diseases or in the absence of a drug-induced increase in gingival volume are a sign of probable inflammatory disease.

The most significant clinical sign of periodontal inflammation is bleeding that occurs following probing⁵³⁻⁵⁵ (Fig 6-8). It is important to note loss of gingival attachment, especially if it is associated with recession, with the insertion of frenum, or with the presence of prosthetic rehabilitation.^{56,57} The presence of interdental necrosis can be a clinical sign of necrotizing ulcerative periodontitis, which can occur in patients who have a depressed immune system (Fig 6-9).

The evaluation of oral hygiene (ie, relationship between the quantity of prominent microbial plaque and the severity of the periodontal damage) is fundamental for diagnosis and forma-



Fig 6-10 Periodontal probing.

tion of a correct treatment plan; modifications in the patient's hygiene habits play a significant role in planning treatment. For this reason, it is necessary to monitor the level of plaque accumulation over time. To monitor the quantity of plaque, various periodontal indexes have been proposed. One of the most effective and widely used methods is the plaque index according to O'Leary et al,⁵⁸ which proposes the complete-mouth plaque score. For each tooth, six points are analyzed and assigned a value of 0 or 1, depending on whether plaque is absent or present, respectively. After all the teeth have been evaluated, it is possible to calculate the percentage of dental surfaces on which plaque is present. With this method, it is possible to monitor the effective capacity of the patient to maintain adequate home control of plaque.

Periodontal probing⁵⁹⁻⁶¹ is essential for the diagnosis of periodontal diseases, because it enables loss of attachment to be assessed. The probe must be used gently,^{62,63} and the whole circumference of the tooth must be probed, while the probe is held at an inclination parallel to the long axis of the tooth (Fig 6-10). The probing depth from the edge of the free gingival margin to the bottom of the pocket and the loss of attachment—the distance between the cemento-enamel junction and the bottom of the pocket—are the clinical parameters that are normally recorded at six points of the circumference. A probing depth of more than 3 mm is significant.⁶⁴ The most significant parameter for the evaluation of the severity of the disease is, however, loss of attachment, which is defined as loss of periodontal support.

Another type of information that can be obtained from probing is furcation involvement.^{65,66} Probing of the furcations allows evaluation of the extent of periodontal damage inside the furcal area; the use of curved probes⁶⁷ is indispensable for probing these areas.

Bleeding on probing is a clinical sign of inflammation that is of great diagnostic importance. By documenting the percentage of the sites that bleed on probing, the dentist can use the bleeding index to monitor the diseased sites in an active phase.^{68,69} Successive measurements of this index provide an objective measure of the efficiency of the therapy to reduce periodontal inflammation.⁷⁰ Recording this information allows the dentist to follow the development of the disease over time.

During periodontal probing, the presence of the gingival recession, defined as the distance between the cemento-enamel junction and the gingival margin, is also recorded; furthermore, in an area of recession, the width and the relationship with the interproximal papillae must be considered. The following classification is widely accepted⁷¹:

Class I: recession that does not extend to the mucogingival line and is not associated with bone or gingival loss in the interdental area (Fig 6-11)

Class II: recession that extends beyond the mucogingival line but is not associated with bone or gingival loss in the interdental area (Fig 6-12)

Class III: recession that extends to or beyond the mucogingival line and is associated with bone or gingival loss in the interdental area and/or dental malpositioning (Fig 6-13)

Class IV: recession that extends to or beyond the mucogingival line and is associated with severe bone or gingival loss in the interdental area and/or severe malpositioning of the teeth (Fig 6-14)

Dental hypermobility is another piece of important information that completes the objective examination. It is evaluated in both the buccolingual and the occlusal directions (Fig 6-15). Mobility that is little more than physiologic is considered class I, mobility that is more accentuated but only in a horizontal sense is defined as class II, and vertical mobility is designated as class III.⁷²

Radiographic examination

The radiographic examination completes the clinical information and is essential to formulation of a treatment plan.⁷³⁻⁷⁶ Radiographs are indispensable for determining the extent and the seriousness of the destruction of the alveolar bone.⁷⁷ A panoramic radiograph provides a good general radiographic view of the oral structures, but it is not sufficiently detailed for periodontal problems. When the clinical examination reveals the presence of periodontitis, it is advisable to carry out a systematic radiographic examination⁷⁸⁻⁸⁰ (Fig 6-16). To reduce distortions to a minimum, the intraoral radiographs must be taken with the parallel long-cone technique and using Rinn film holders. The periapical radiograph reveals the height of the interdental septum and indicates the width of the periodontal

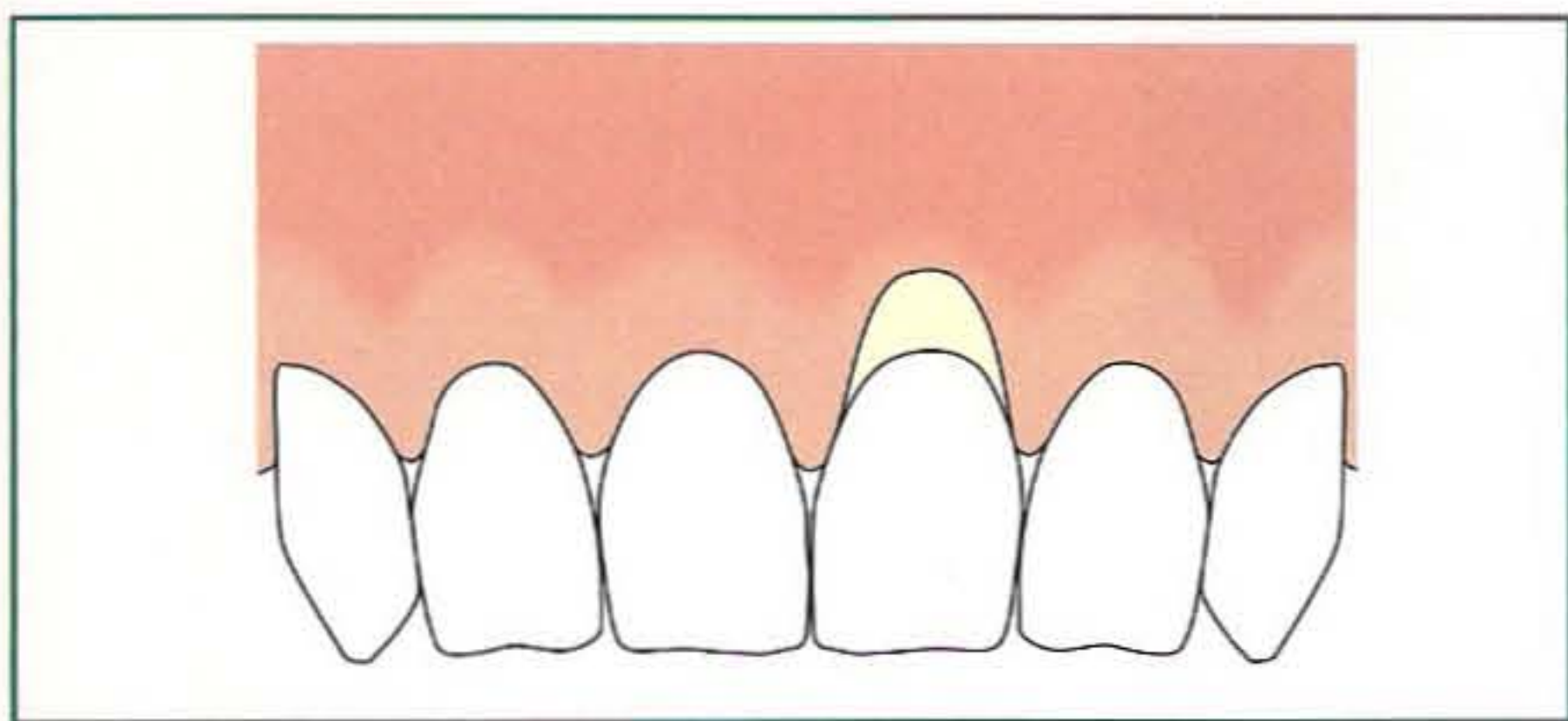


Fig 6-11 Class I recession.

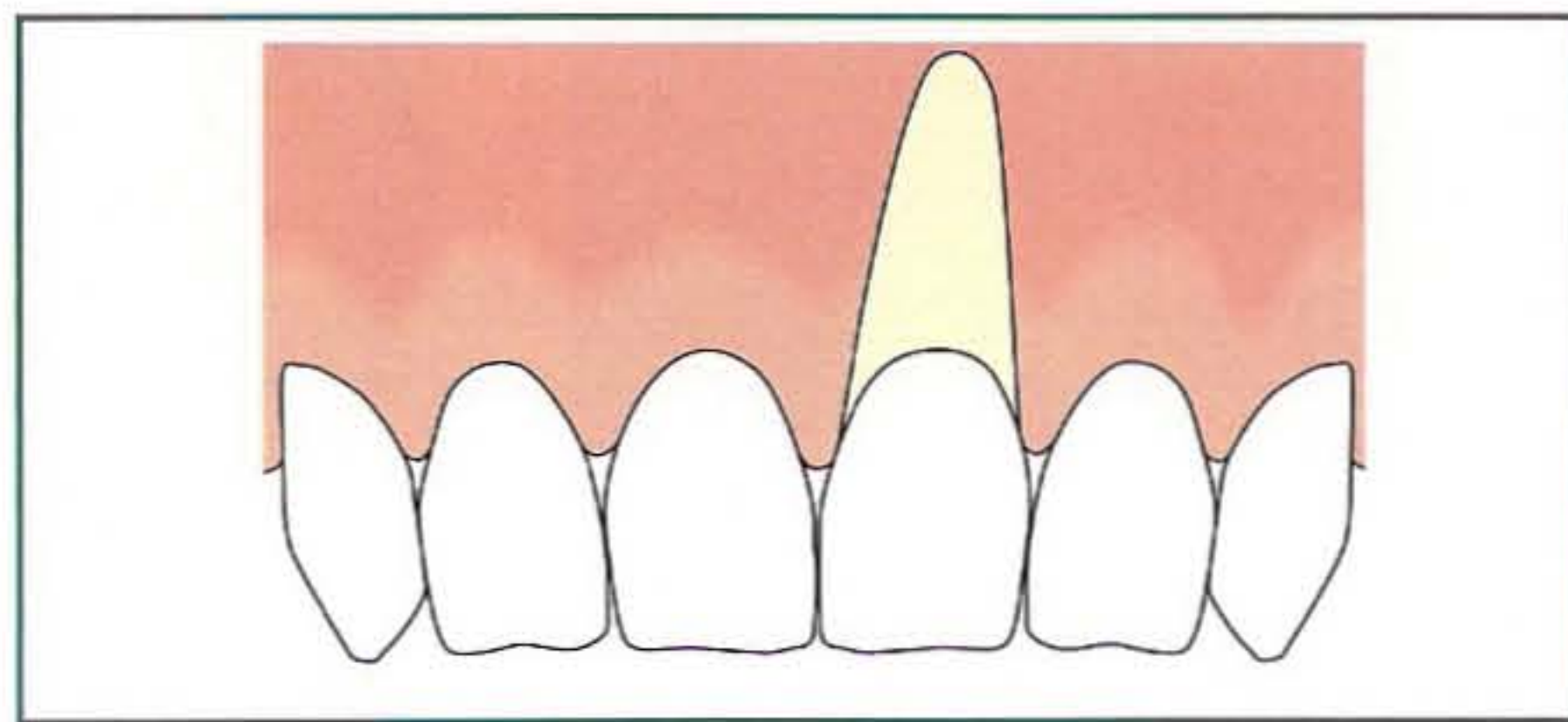


Fig 6-12 Class II recession.

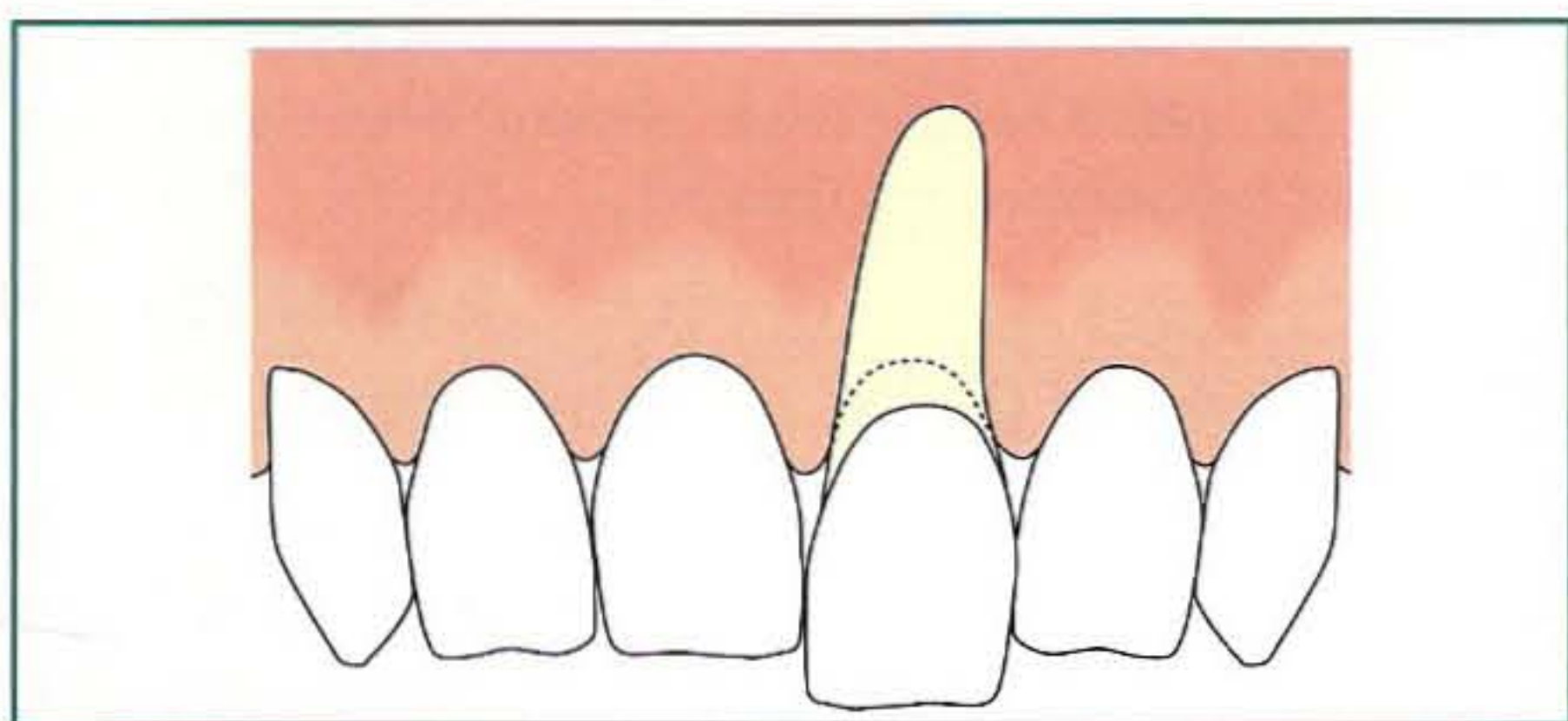


Fig 6-13 Class III recession.

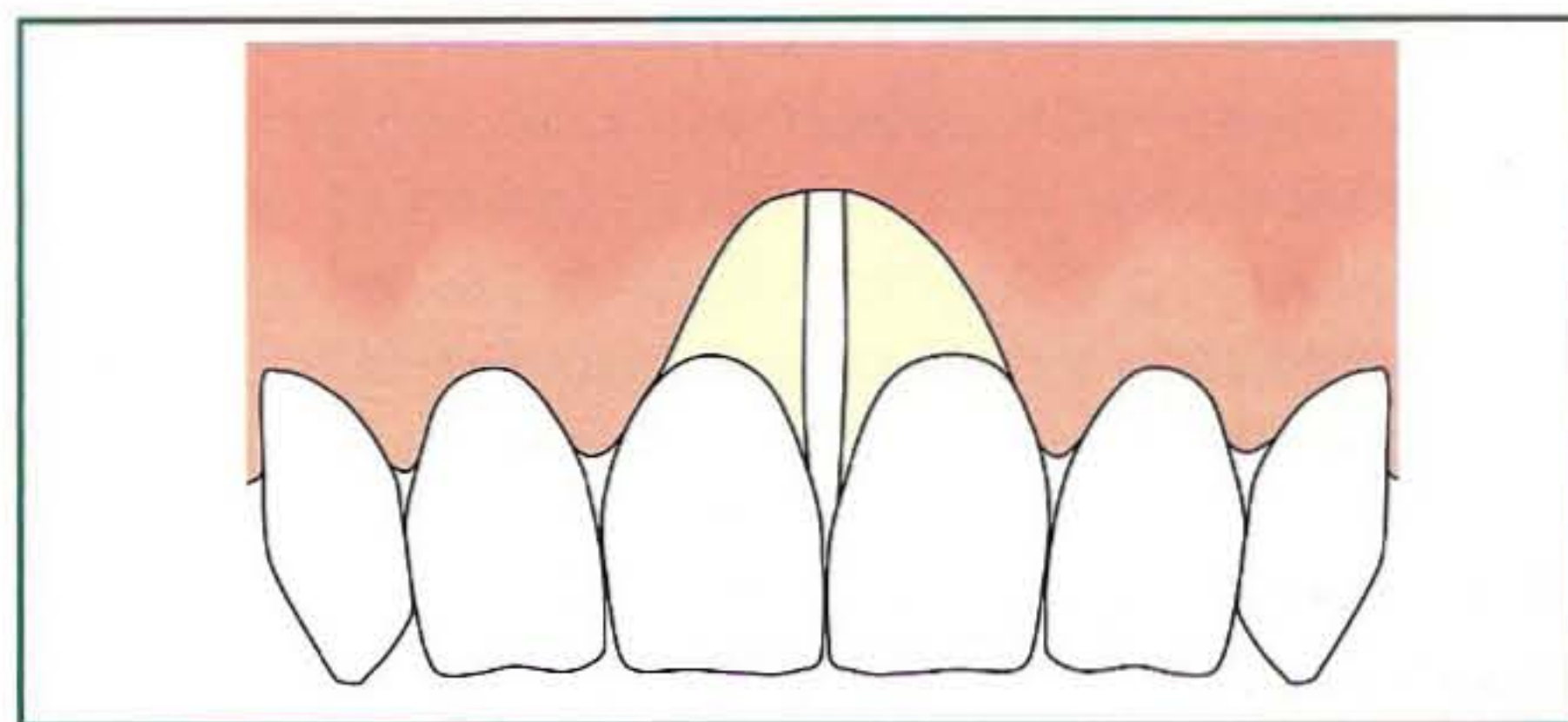


Fig 6-14 Class IV recession.



Fig 6-15 A rigid instrument is used to evaluate dental mobility.

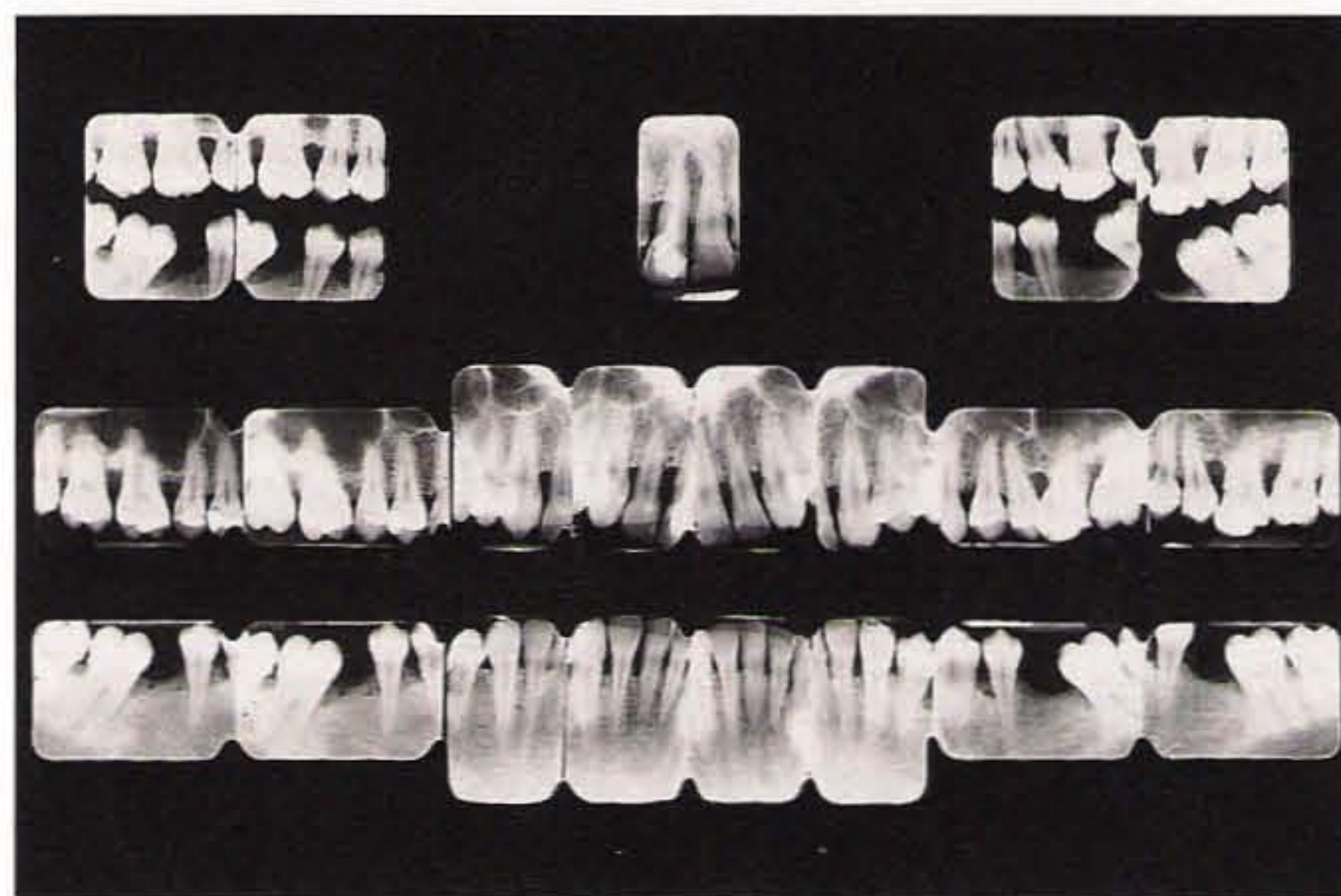


Fig 6-16 Systematic radiographic examination of patients affected by chronic adult periodontitis.

space.⁸¹ The furcal defects can be visualized radiographically, but only when the loss of attachment and alveolar bone between the roots is very advanced. The radiographic examina-

tion has anatomic limits (the effect of masking by nearby structures) and objective technical limits, so the information obtained must always be correlated with clinical data.

Laboratory examinations

Microbiologic examinations

Microbiologic investigation is not prescribed for most periodontal patients. There is not enough evidence to recommend the routine clinical use of microbiologic tests, even if these can help the dentist to define the diagnosis of the periodontal disease and to guide the therapy for specific patients. In effect, microbiologic tests are more often recommended for patients with early-onset periodontitis or rapidly progressing periodontitis; patients with early-onset periodontitis have a higher number of *Actinobacillus actinomycetemcomitans*,⁸² whereas adults with severe periodontitis may have a higher number of *B forsythus*, *Porphyromonas gingivalis*, *P intermedia*, *Eikenella corrodens*, *Eubacterium* sp, *Peptostreptococcus micron*, and spirochetes. It is important to know that these microorganisms are responsible for periodontitis and are sensitive to specific antibiotics.^{83–88} The most reliable methods of investigation used for bacteriologic diagnosis are culture and genetic methods.⁸²

Immunologic and genetic tests and biochemical analysis

Although immunologic and genetic testing and biochemical analysis have been introduced as possible diagnostic aids, there are no studies that demonstrate the use of these tests in daily clinical practice; in the future, however, they could become important indicators of predisposition to the disease and disease activity.^{89–91}

Medical considerations and consultation

The patient's history can indicate a need for medical consultation. Some systemic diseases, including cardiovascular diseases, insulin-dependent diabetes (especially if not controlled), osteoporosis, respiratory diseases, bleeding disorders, and immunologic diseases, can influence the diagnosis and treatment plan for patients with periodontal disease.

Treatment Planning

Gingivitis is reversible and therapy consists primarily of eliminating or reducing the causal factors. The treatment of periodontitis is characterized by a phase of active therapy aimed at arresting the progression of the disease and correcting and, where possible, regenerating the damaged structures, and by supportive periodontal therapy to maintain long-term success.^{92,93} Ramfjord et al⁹⁴ proposed a scheme for therapy, which can be divided into four phases:

1. Systemic
2. Causal
3. Corrective
4. Maintenance

Systemic treatment phase

In this phase, the systemic diseases and the risk factors that can influence pathogenesis, prognosis, and periodontal disease therapy are considered. Diabetes,^{93,95} for example, especially if not controlled, besides being associated with a greater severity and extent of periodontal disease, can affect the healing process. Cigarettes often present an obstacle to adequate therapy, and the patient should cease smoking before a complex periodontal treatment plan is initiated.

Causal therapy phase

This phase includes educating the patient in how to maintain oral hygiene at home, the extraction of teeth that are no longer savable, the positioning of a provisional prosthesis, endodontic therapies, scaling and root planing, and administration of local and systemic antimicrobial agents. Restoration of carious teeth and correction or replacement of defective restorations is also included in this phase. In some cases, these interventions can be carried out provisionally until correction of the periodontal architecture is completed.

Corrective phase

The corrective phase includes procedures that are designed to correct the effects of disease on the periodontal tissues, on the teeth, and on the masticatory system. This includes occlusal and orthodontic therapy, periodontal surgery, and implants.

Maintenance phase

Maintenance is essential in every phase of periodontal treatment. A periodontal therapy can fail if it is not followed by adequate control of plaque at home and by adequate follow-up with therapeutic support. A professional examination every 3 to 4 months seems to be adequate. At each examination, all the occlusal and periodontal parameters must be monitored (plaque index, bleeding index, probing depth, and attachment level). The patient must be continually encouraged to maintain adequate hygiene at home. If there are sites with worsening parameters, additional scaling and root planing must be performed.

Fig 6-17 Toothbrushing using the modified Bass technique. (a) Vibrating movements are needed to disaggregate plaque in the sulcus; (b) rotational (miniscrub) movements are used in the apicocoronal area to remove plaque.



Prevention

Patient motivation

Inflammatory periodontal diseases are pathologic conditions that can often be prevented. It therefore follows that the high prevalence of these diseases, above all in adults, shows that both dentists and patients need better understanding of ways to obtain and maintain a good state of periodontal health.

For the dentist, this implies a greater awareness of how to deal more efficiently with the problem of patient motivation, while, for the patient, it implies making an effort to regularly carry out preventive methods in terms of professional and home oral health.⁹⁶ To create good oral health, the dentist must be able to guarantee the patient's correct and regular practice of oral hygiene at home by continually encouraging cooperation. For this to be successful, the dentist must understand the patient's habitual psychology and motivations. Indeed, the success of oral hygiene is directly linked to what the patient sees as being important for his or her health and also to the patient's sense of satisfaction when fulfilling objectives.

Different studies⁹⁷⁻⁹⁹ have shown that only through continual encouragement of the patient's motivation can the dentist guarantee an adequate state of oral health; hygiene programs that last a short time without adequate follow-up only improve the situation temporarily.

Mechanical removal of plaque

Plaque removal is the most widely used preventive measure in periodontics. A motivated patient is able to effectively remove plaque from the dental surface by brushing with both a manual and an electric toothbrush.¹⁰⁰ The toothbrush must have a relatively small head and synthetic fiber bristles. Among the advantages of synthetic fibers, which must have rounded tips,

are the absence of the central cavity that is present in natural bristles and a lower liquid absorption. When a toothbrush loses its initial form and consistency, it has to be replaced. This happens after 8 to 10 weeks.

Opinions about the effectiveness of electric toothbrushes differ greatly. An electric toothbrush seems to have some advantage for patients who exhibit poor plaque control, are motor deficient, or have an orthodontic appliance.¹⁰¹⁻¹⁰³

The brushing technique that is most advised and efficient is the modified Bass technique, which is carried out by giving the toothbrush a light vibrating mesiodistal movement, inclining the bristles toward the interior of the gingival sulcus, and completing the movement with an apicocoronal rotation to clean the crown (Fig 6-17).

Dental floss is the best method for cleaning the interproximal spaces (Fig 6-18). Where there is loss of attachment, the efficiency of floss diminishes as the surface of the root becomes more concave. In such areas, interdental brushes are of help for patients with moderate or severe attachment loss (Fig 6-19). The combined use of the toothbrush and dental floss or an interdental cleaner or brush has been proven more effective in removing plaque than the use of a toothbrush alone^{104,105}; this combination is indispensable to obtaining adequate removal of bacterial plaque.

Oral irrigators can be of use to denture patients for effective removal of nonadherent residue from the teeth in contact with prosthetic clasps and to patients with a fixed orthodontic appliance.

In some patients, for a variety of reasons, it is difficult or impossible to obtain adequate mechanical plaque control. In these cases, chemical agents can aid the removal of plaque.¹⁰⁶⁻¹⁰⁹ A topical chemotherapeutic agent should ideally be nontoxic, nonallergenic, and nonirritating; should efficiently and significantly reduce the plaque and gingivitis indexes with



Fig 6-18 (a and b) Use of interdental floss.

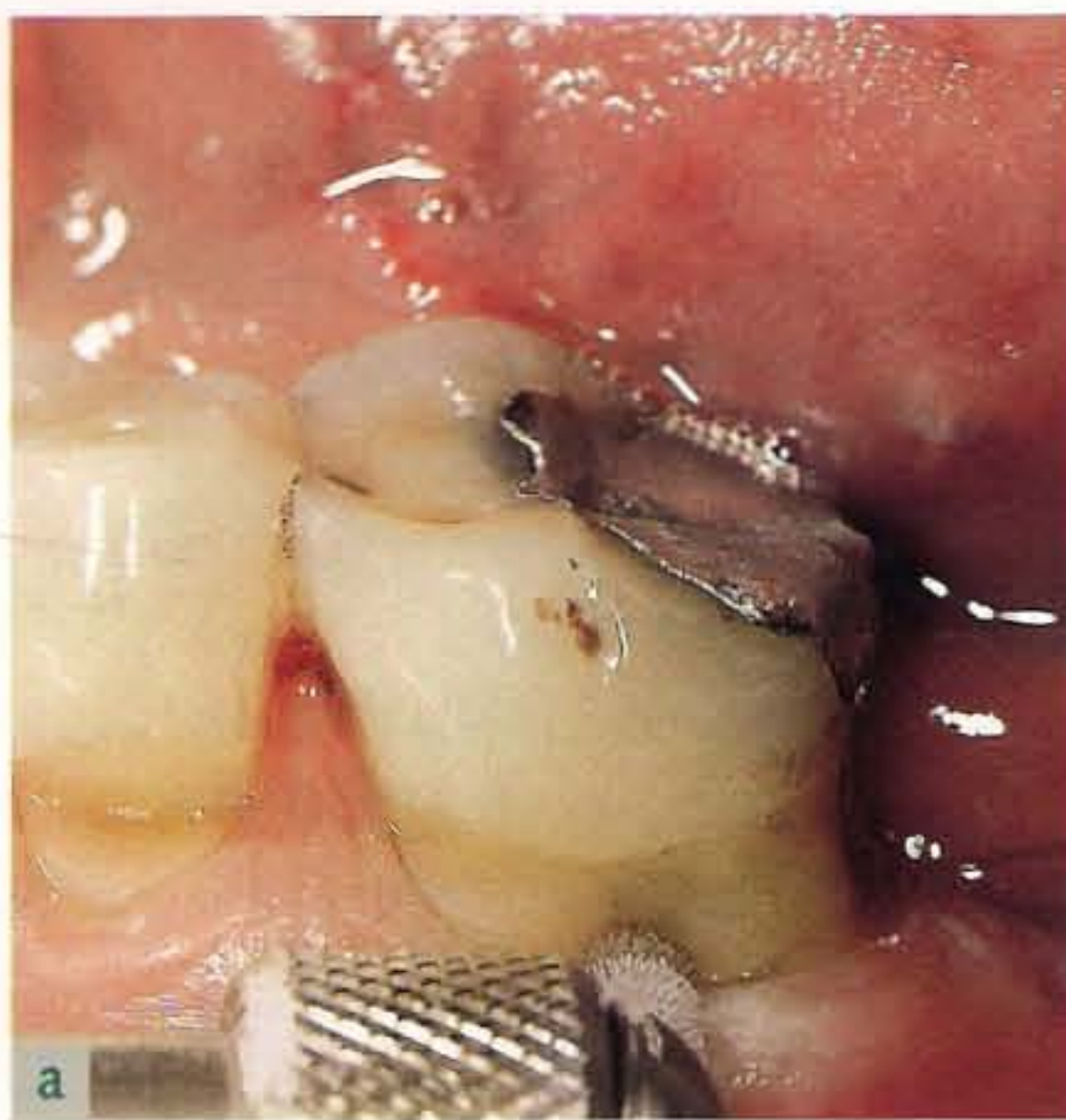


Fig 6-19 (a and b) Use of an interproximal brush in a class III furcation defect.

a lasting effect; should have specific effects on the pathogenic flora; should have a pleasant taste; and should be practical to use and affordable. Chlorhexidine is the antiplaque agent that has been most widely studied and is available as toothpaste or in the form of liquid and spray. The use of this agent has been shown to significantly reduce plaque deposits and gingival inflammation, and it is considered one of the most efficient topical chemotherapeutic agents.¹⁰⁹⁻¹¹³ Among the new chemotherapeutic agents being investigated, the most promising seems to be delmopinol (morpholinoethanol).¹¹²⁻¹¹⁸

Periodontal Support Therapy

Clinical studies carried out over a long period of time have shown that good maintenance is an integral part of periodontal treatment.¹¹⁹⁻¹²⁷ More specifically, the American Academy of Periodontology¹²⁸ defines three objectives of support therapy:

1. Preventing or minimizing the development of the disease in patients who have completed the therapeutic phase of treatment for gingivitis or periodontitis
2. Preventing or minimizing tooth loss
3. Increasing the probability of locating and treating other diseases of the oral cavity

A good deal of evidence shows that patients who have developed periodontitis are subject to a higher risk of recurring disease¹²⁹ even after active therapy; as a consequence, they must undergo support therapy with continual professional input, hygiene guidance, motivation, stimulation, and instruction on how to maintain hygiene at home.

The most useful aspect of support therapy is the monitoring of the periodontal parameters with the aim of maximizing the effect of therapeutic interventions. Support therapy must always be adapted to individual patients. It must be evaluated in relation to the patient's compliance (the patient's capacity to maintain a high level of oral hygiene at home),^{121,130} the loss of attachment in relation to age, the bleeding index values, the

prevalence of residual pockets, and the presence of systemic conditions (diabetes) or environmental conditions (smoking). Even for patients who exhibit good compliance, the professional maintenance examinations must take place every 4 months.

Nonsurgical Periodontal Therapy

Considering that periodontal disease is an infection induced by bacterial plaque, professional removal of plaque and hygiene at home are the most effective ways to obtain and maintain periodontal health.^{131–135} Etiologic therapy consists of subgingival and supragingival scaling as well as planing roots with manual, sonic, and ultrasonic instruments that remove plaque, tartar, and endotoxins and create a root surface that is biologically appropriate for restoring a healthy attachment.^{136–144} In some cases, chemotherapy can be useful, including topical applications of antiseptics^{145–147} or use of a local-delivery system for medicines.^{148–151} The systemic approach includes the use of antibiotics or modulators of inflammatory reactions.^{152–156}

Not all patients react well to nonsurgical periodontal therapy; some may exhibit a low level of compliance in maintaining adequate oral hygiene or may not return regularly for hygiene examinations.^{121,157}

Single-rooted teeth and multirooted teeth with healthy furcations react better to nonsurgical therapy and are easier to maintain than are multirooted teeth with compromised furcations.^{158–162}

The success of mechanical therapy depends much on the ability and care of the operator.^{163,164} The 1996 World Workshop of the American Academy of Periodontology concluded that sonic and ultrasonic instruments have the same efficacy as manual instruments; it would seem, however, that the use of manual mechanical therapy together with ultrasonic therapy is able to produce better results.^{165,166}

The usefulness of combining antimicrobial and mechanical therapy has been shown.^{167,168} Among the diverse antimicrobial agents, the most efficient and most commonly used is chlorhexidine. Its antiplaque action seems to depend on the antimicrobial action that persists in the oral cavity. This molecule does not produce toxicity at a systemic level, and there is no relevant microbial resistance. The most significant collateral effect is the pigmentation of the tongue and the surfaces of the teeth¹⁶⁹ (Fig 6-20).

Antimicrobial agents designed for local release, positioned directly at the site of infection can, if used correctly, reduce probing depths and bleeding. These antimicrobial agents help to reduce or to eliminate the concentration of bacteria inside pockets that are difficult to access with manual, sonic, or ultrasonic instruments.^{145,147}



Fig 6-20 Tooth discoloration resulting from use of chlorhexidine.

Some authors have reported that the clinical results obtained with nonsurgical therapy seem to be the same as those obtained through surgical therapy for pockets of less than 4 mm; the difference in outcomes is statistically significant for pockets of greater depth.¹⁶² Other authors did not find statistically significant differences in the long term between these two types of therapy.¹⁷⁰ More recent data, obtained from a longitudinal study lasting 12 years,¹⁷¹ show that surgical therapy is more effective than nonsurgical therapy in cases of serious periodontitis.

To summarize, it would seem that nonsurgical therapy and surgical therapy provide almost identical results, although surgical therapy seems to provide a more favorable prognosis in pockets with a probing depth greater than 5 mm.

Surgical Periodontal Therapy

Indications

Surgical therapy is used when nonsurgical methods are not able to create stable conditions of periodontal health over time (ie, persistent bleeding on probing and deep pockets that do not improve or that worsen).^{172,173}

Once the nonsurgical therapeutic phase has been completed and a sufficient amount of time has passed to observe the reaction of the tissues (at least 3 to 6 months), and the capacity of the patient to maintain an adequate plaque index (less than 25%) has been ascertained, it is necessary to reevaluate the case.^{163,172,174–177} The patient must be briefed with regard to the benefits and the risks of surgical therapy and must give informed consent. The patient must be given clear information about discomfort and complications, drug therapy, modifications to the diet, reduction of smoking, and home care.

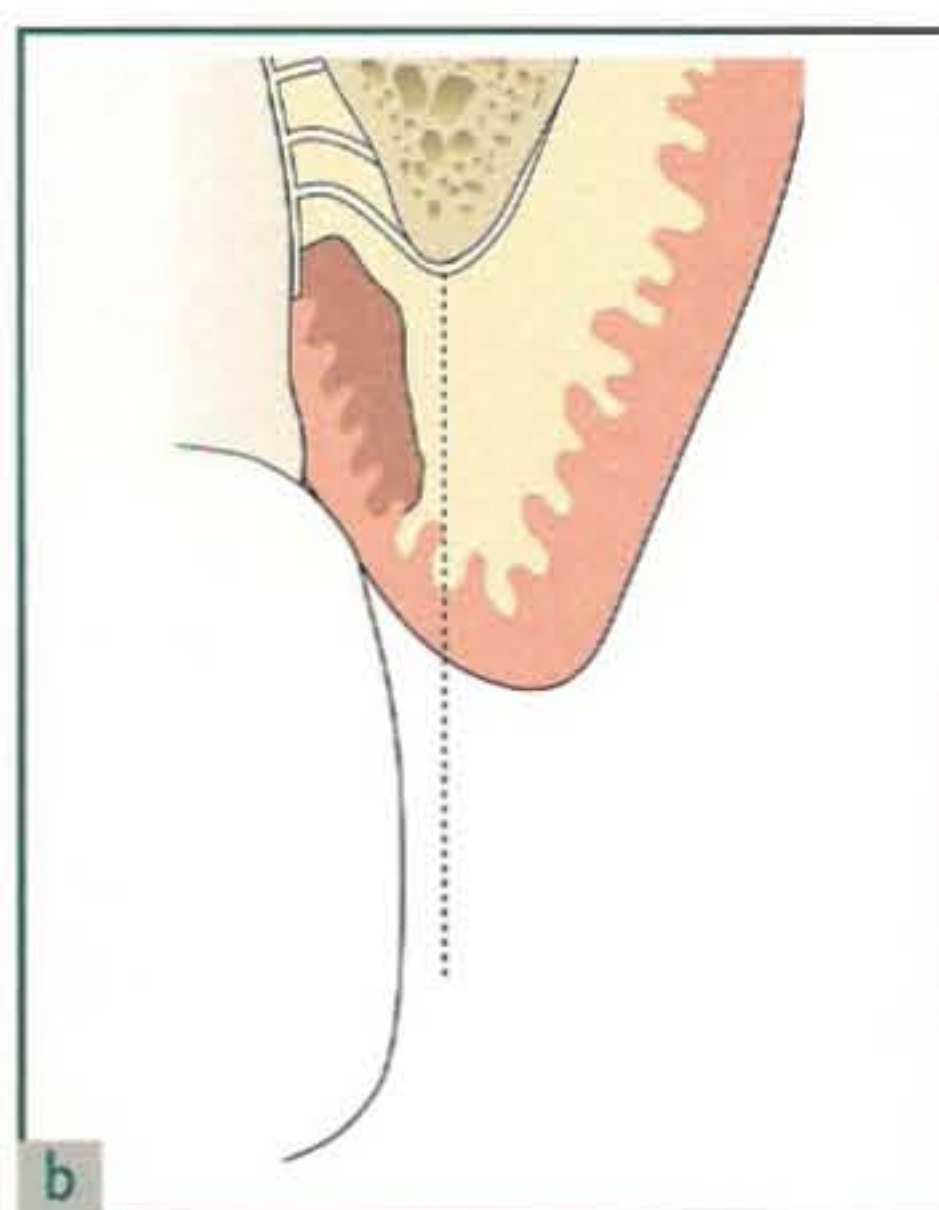
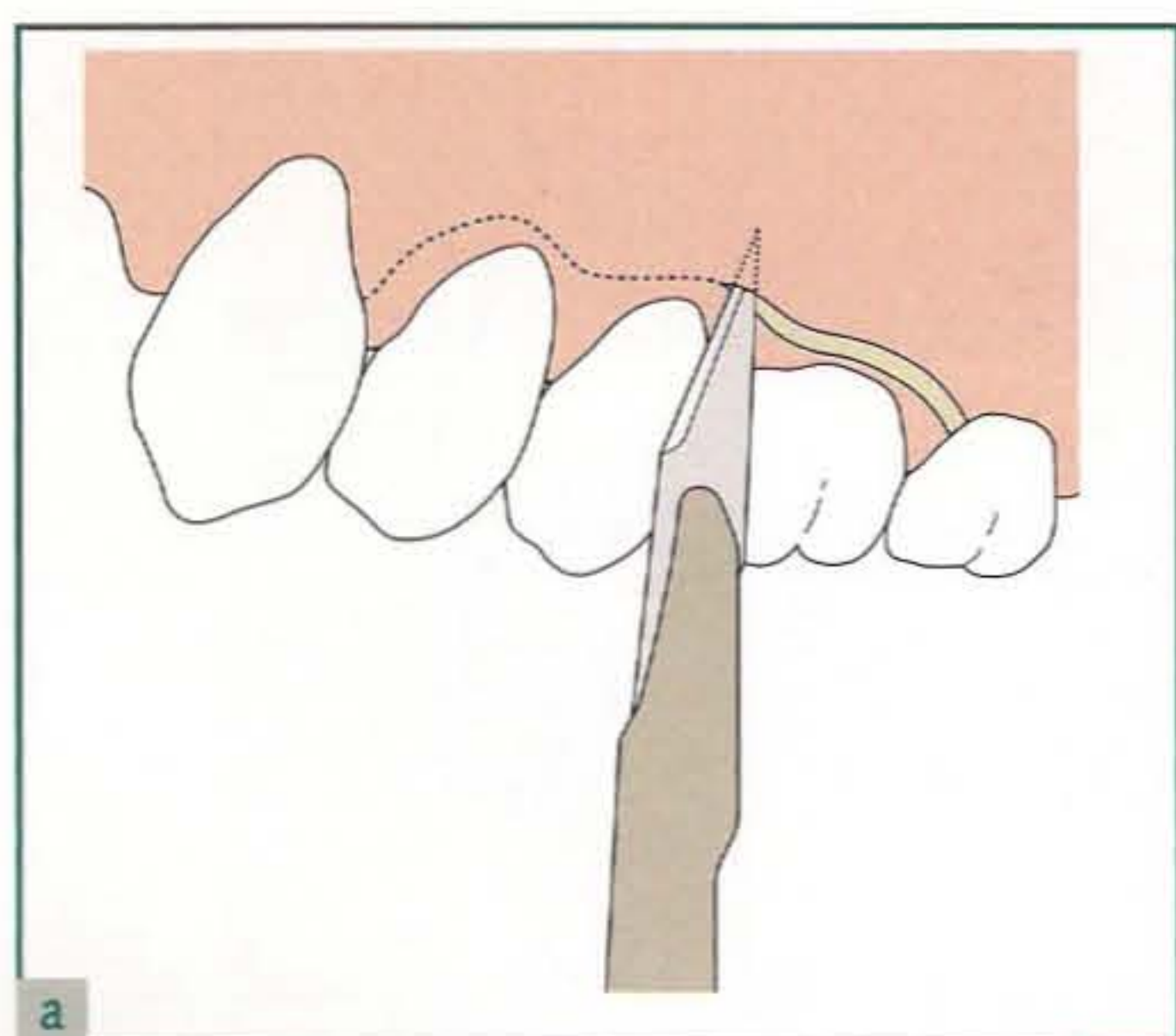


Fig 6-21 Modified Widman flap. (a and b) The initial incision is made 0.5 to 1.0 mm from the gingival margin.

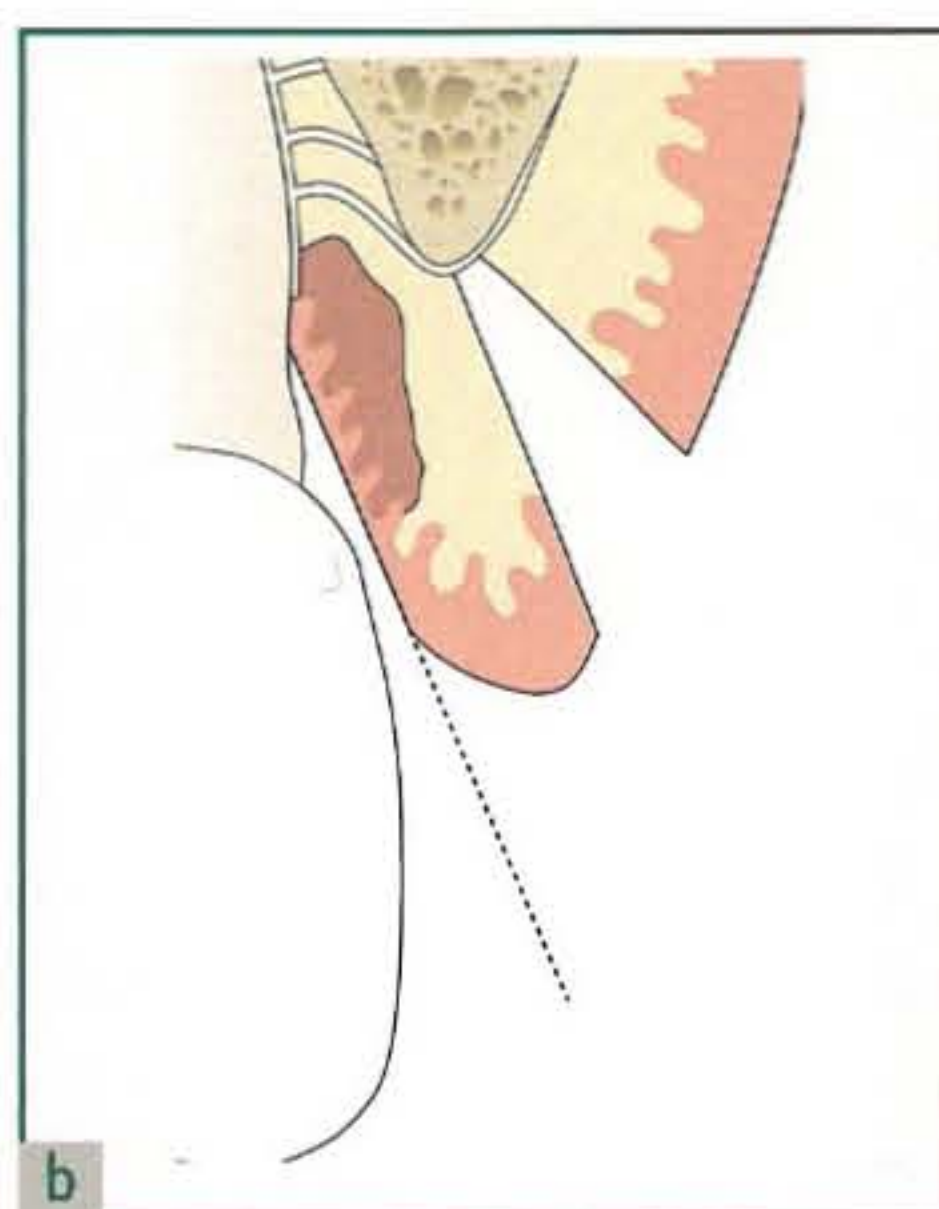
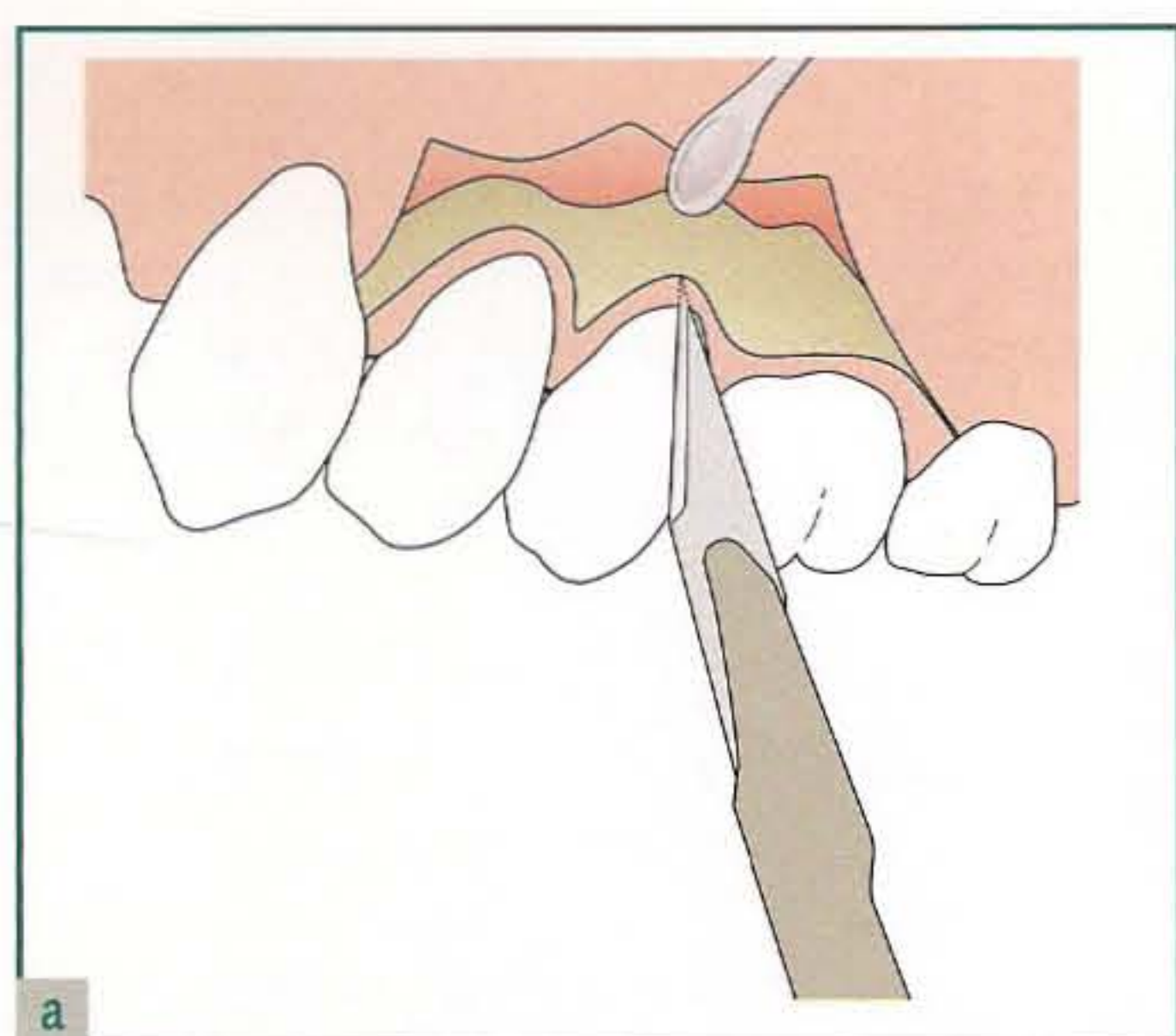


Fig 6-22 Modified Widman flap. (a) The flap is removed and then (b) the second intrasulcular incision is carried to the osseous crest.

The objectives of periodontal surgery are:

- To obtain direct access for root planing and scaling.
- To restore favorable bone and gingival architecture.
- To recover periodontal support.

While resective and reconstructive bone surgery are to be performed by a specialist, root planing and polishing with direct access can be undertaken by a general dentist using the modified Widman flap¹⁷⁸ (Figs 6-21 to 6-24). This procedure allows the removal of the inflamed epithelium of the pocket, preserving the greatest amount of periodontal tissue possible, and therefore is recommended primarily when esthetics is of primary importance. Nevertheless, it does not allow complete elimination of the pocket or restoration of the physiologic bone structure, and induces healing with a long junctional epithelium. If accurate root planing with direct visual access is carried out, however, it is often possible to revive stable conditions of periodontal health.

Preprosthetic surgery in dentate patients

Every dentist must be capable of reaching a correct periodontal diagnosis, but the therapeutic treatment of the disease can be carried out by a specialist if the specific abilities of the dentist and the wishes of the patient dictate this. Nevertheless, there exist some preprosthetic situations in which the use of surgical procedures can be recommended even in the absence of disease; these operations, undertaken for functional and esthetic reasons, can be carried out by general dentists.

These procedures are aimed at modifying the profile of the alveolar bone or the position and quantity of the soft periodontal tissues, with the aim of optimizing the patient's adaptation to the subsequent prosthetic rehabilitation.¹⁷⁹

Resective surgical procedures

Operations that are characterized by the removal of bony tissue are based on the concepts of osteoplasty and ostectomy.¹⁸⁰⁻¹⁸² Osteoplasty¹ consists of the removal of bony tissue without involving the dental supporting bone, aimed at reshaping the

Fig 6-23 Modified Widman flap. (a) A third incision is made perpendicular to the root surface (b) to permit removal of the secondary flap.

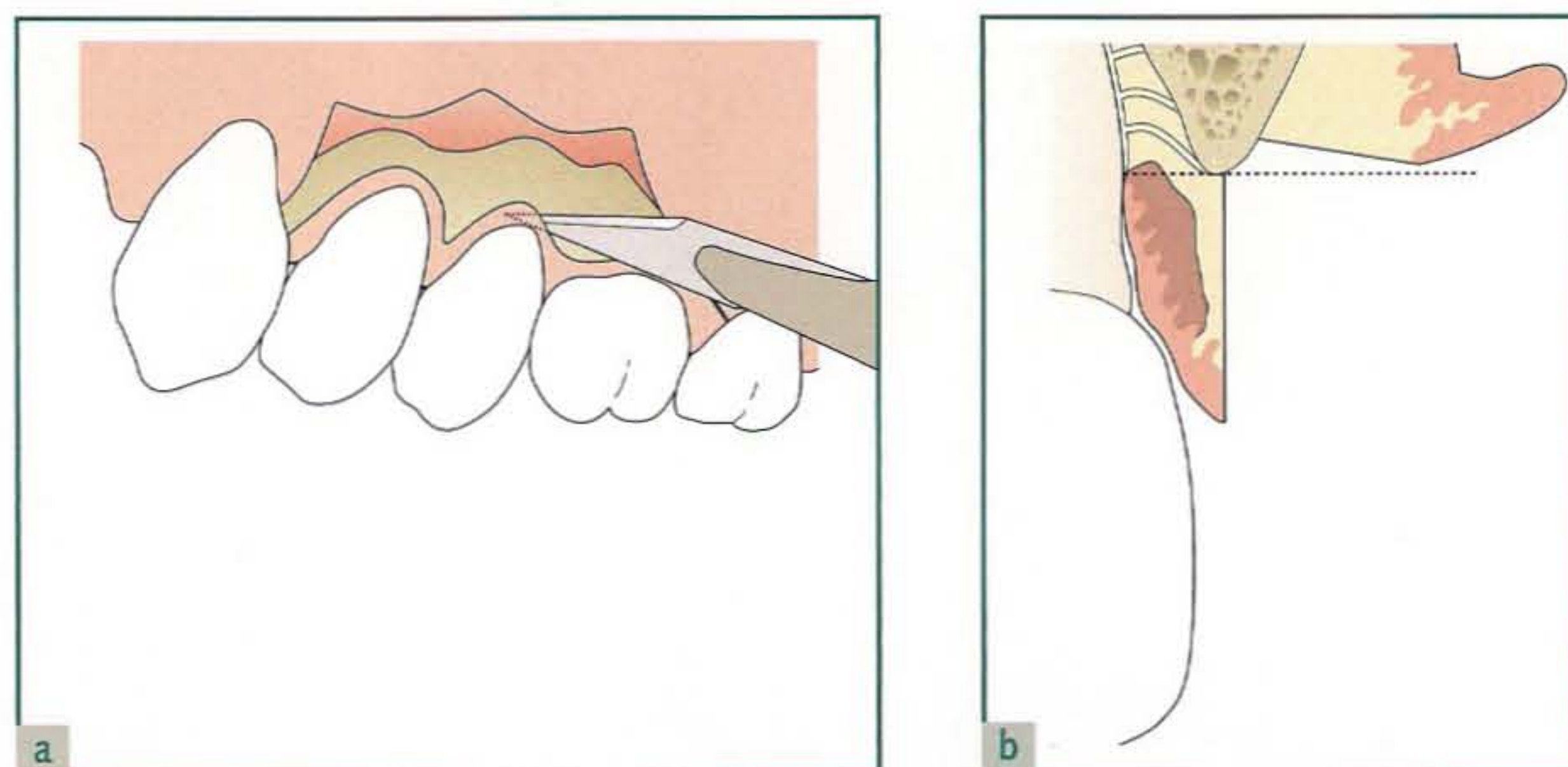
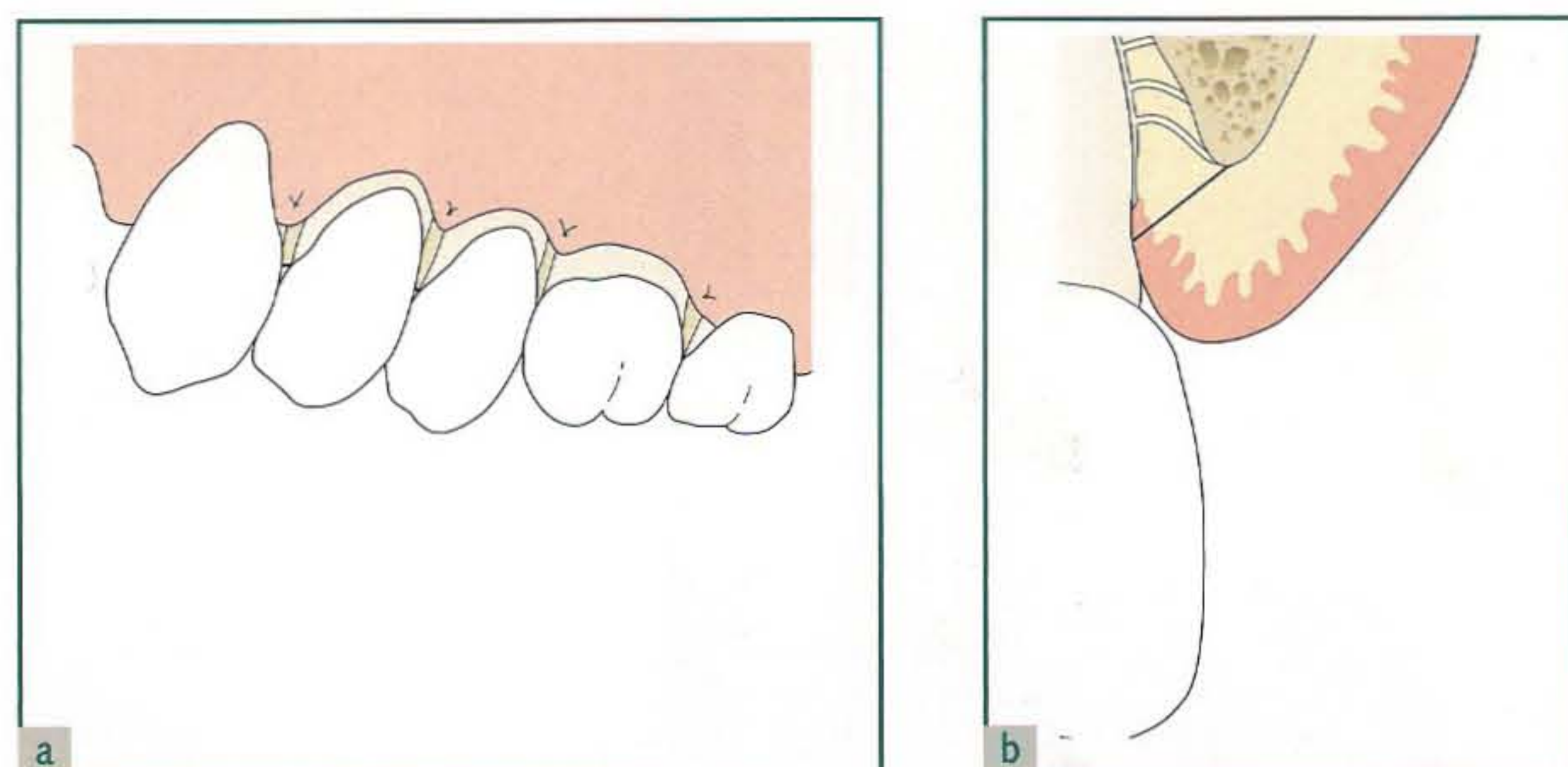


Fig 6-24 Modified Widman flap. After the bone defect is cleaned and the root surface is planed, (a and b) the flaps are sutured to completely cover the bone.



alveolar process. Osteotomy¹ is a resection of alveolar bone with the aim of modifying the position of the supporting bone. All procedures that involve removal of bony tissue bring about an inflammatory reaction characterized by superficial necrosis of the alveolar crest with osteoclastic resorption, followed by deposition of bony tissue that completes the remodeling process.¹⁸³⁻¹⁸⁵ Although the consequent loss of bone is not very severe (from 0.5 to 0.8mm),^{186,187} these procedures trigger very slow healing processes that can take several months to complete and for a stable situation to be reached.¹⁸⁸⁻¹⁹²

Surgeries that aim at reducing the soft periodontal tissues can be divided into two categories: gingivectomy and gingivoplasty.¹⁹³⁻¹⁹⁸ Gingivectomy¹ involves the surgical removal of a portion of the gingiva, including all or some of the sulcus or of the gingival component of the periodontal pocket. Gingivoplasty¹ involves the remodeling of the gingival profile with the aim of recreating a functional and esthetic form without a true excision of tissue. About 2 weeks are necessary to restabilize the sulcular epithelium and about 35 to 40 days for the reconstitution of the junctional epithelium.^{199,200} It is

obvious, therefore, why the healing process that follows soft tissue surgery²⁰¹⁻²⁰³ is quicker than that which follows operations that involve or expose bony tissue,^{183,192,204} even if it is important to remember that the process of complete maturation and stabilization of the soft tissues can last for several months.

The resective procedures that are most used in preprosthetic surgery are lengthening of the clinical crown and reduction in volume of the alveolar crest.

Lengthening of the clinical crown

Lengthening of the clinical crown is carried out to correct functional and esthetic problems by moving the apical margin of the associated gingiva and, if indicated, surgically removing bony and/or gingival tissue.

For a fixed prosthetic rehabilitation to be successful, abutments that are sufficiently retentive (3 to 4 mm of healthy dental coronal structure) are necessary,²⁰⁵⁻²⁰⁸ as is respect for the biologic width, which assures periodontal health^{179,209-213} (Fig 6-25).

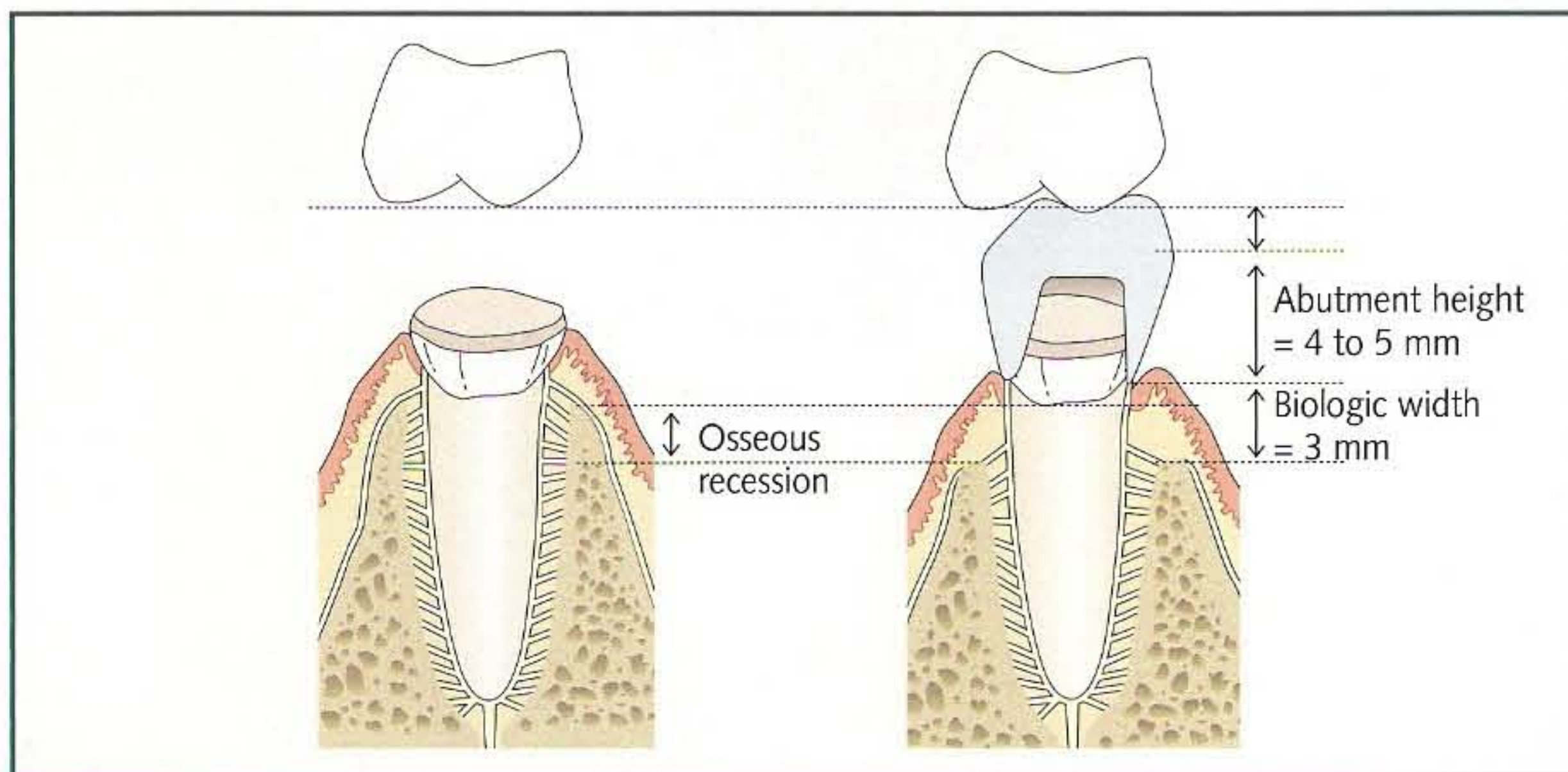


Fig 6-25 Lengthening of the clinical crown. (a and b) The primary incision is determined by the height of the abutment, the thickness of the prosthetic restoration, and the biologic width. It is necessary to create a space of at least 9 mm from the occlusal plane to the alveolar crest.

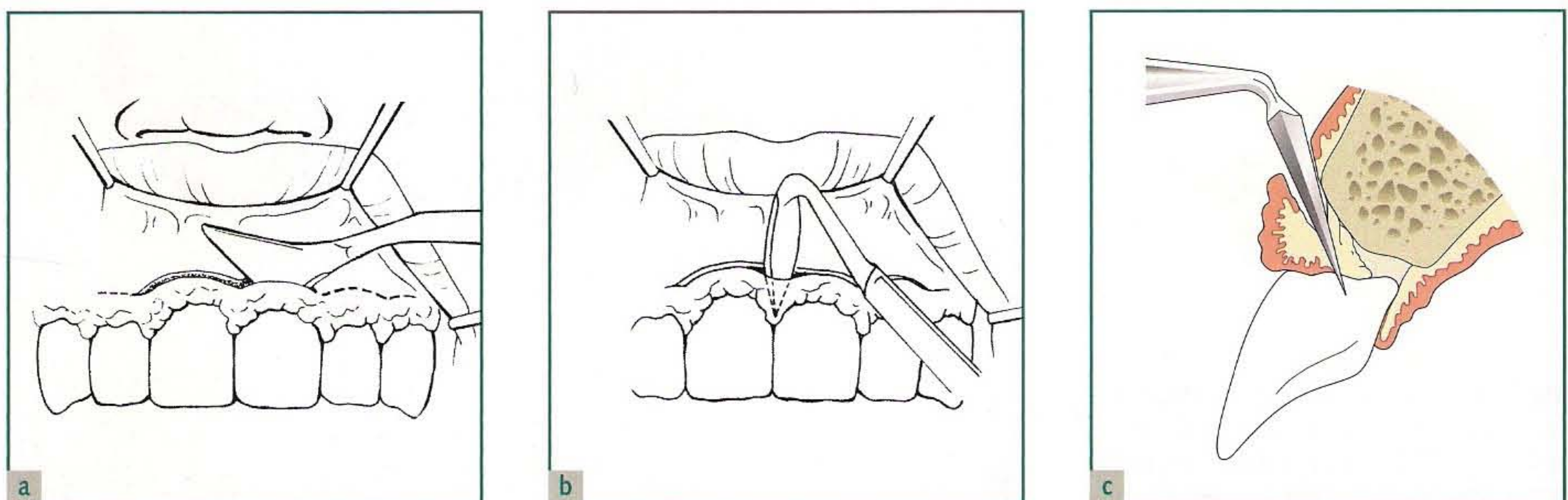


Fig 6-26 (a) The external paramarginal incision with a scalpel follows the scalloping of the future gingival margin; (b) frontal view of the completion of the incision in the interdental area; (c) lateral view of the interdental incision.

Coronal fracture, deep caries, and short clinical crown arising from excessive gingival tissue (altered passive eruption, gingival hypertrophy) are indications for surgical lengthening of the clinical crown.²¹⁴⁻²²¹ Deep probing, which is carried out after administration of an anesthetic, indicates the level of marginal bone, and in this way the level of the new gingival and bony margins can be decided. In this phase, the length of the root trunk must be evaluated in multirooted teeth to avoid furcation involvement and the creation of secondary complications.

Gingivectomy

To obtain 1 to 2 mm of lengthening at the clinical crown, in the presence of a gingival sulcus of 3 or 4 mm and adequate attached gingiva,^{222,223} a gingivectomy¹⁹⁶ is sufficient. This surgery¹⁹³⁻¹⁹⁵ allows, after administration of local anesthesia, measurement of the depth of the sulcus and the creation of bleeding points by perforating the gingiva at the level where it

is expected that the new gingival margin will lie (Fig 6-26). The internal or external bevel incision must be carried out in a way that gives the gingiva a festooned and thin margin. The separated marginal tissue is removed with cures or scalers. Because it is not necessary to raise a flap, it is unnecessary to suture the area (Fig 6-27).

Apical repositioning flap

This procedure is appropriate for patients who have a low amount of keratinized gingiva or who need bone removal. The clinical crown can be lengthened through an apical repositioning flap. The initial sulcular or paramarginal internal bevel incision is made, and then one or two vertical incisions are made to release the flap. The flap can be raised to full or partial thickness. The partial-thickness flap, which involves a more complex process, permits the use of periosteal sutures, which allow bone resection and thus more precise and stable positioning²²⁴⁻²²⁸ (Fig 6-28, page 114).

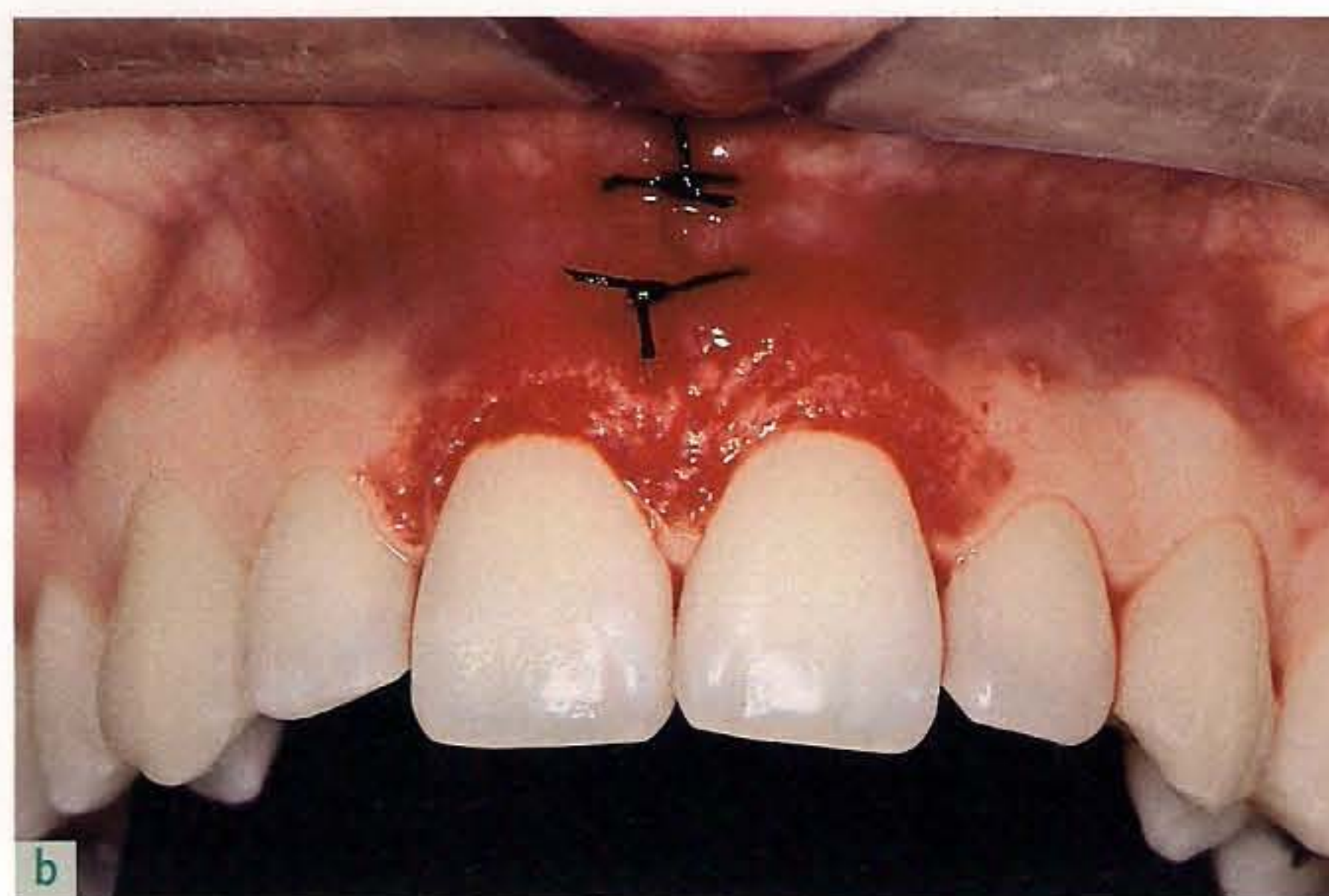


Fig 6-27 Gingivectomy and gingivoplasty in the case of an altered passive eruption. (a) Preoperative view; (b) postoperative view; (c) healing after 7 days; (d) healing after 24 months.

Reduction in the volume of the alveolar crest and removal of exostosis

Surgical reduction of the alveolar crest can be recommended when the crest is likely to interfere with the positioning of a prosthesis for a reduced coronoapical space.²²⁹ Rarely, crests that are very large have to be reduced buccolingually to create a better emergence profile for the prosthesis. If a limited reduction of the soft tissues is not sufficient, it is necessary to raise a full-thickness flap and use osteoplasty to correct these defects.

Tori and exostoses that may interfere with the positioning and the stability of partial prostheses can be removed with this procedure.²³⁰

Augmentative surgical procedures

There are some procedures that aim at increasing the dimensions of both the bony tissue and the periodontal soft tissues to optimize the stability and the esthetics of rehabilitation.²³¹ The

most common of these procedures are interventions that increase the volume of the alveolar crest and mucogingival procedures to restore or increase the marginal gingiva.

Interventions to increase the volume of the alveolar crest

Extraction or traumatic removal of a tooth is always followed by resorption of the alveolar bone that can change the profile of the crest and create esthetic problems.²³² Correction of the crestal profile can be achieved by means of mucogingival surgical techniques. Those that are used most often are free onlay grafts and subepithelial connective tissue grafts.

The free soft tissue graft removed from the palate or from the tuberosity area can be sufficient to reconstruct an edentulous crest, in cases where the amount of resorption is modest.^{233–236} Such grafts must be planned with care, and the alveolar crest obtained after the surgery must be thicker and more



Fig 6-28 Lengthening of the clinical crown. (a and b) Preoperative views; (c) partial-thickness vestibular flap; (d) thinned palatal flap; (e and f) osteotomy and osteoplasty; (g and h) sutures; (i and j) healing after 12 months with the prosthesis in situ.

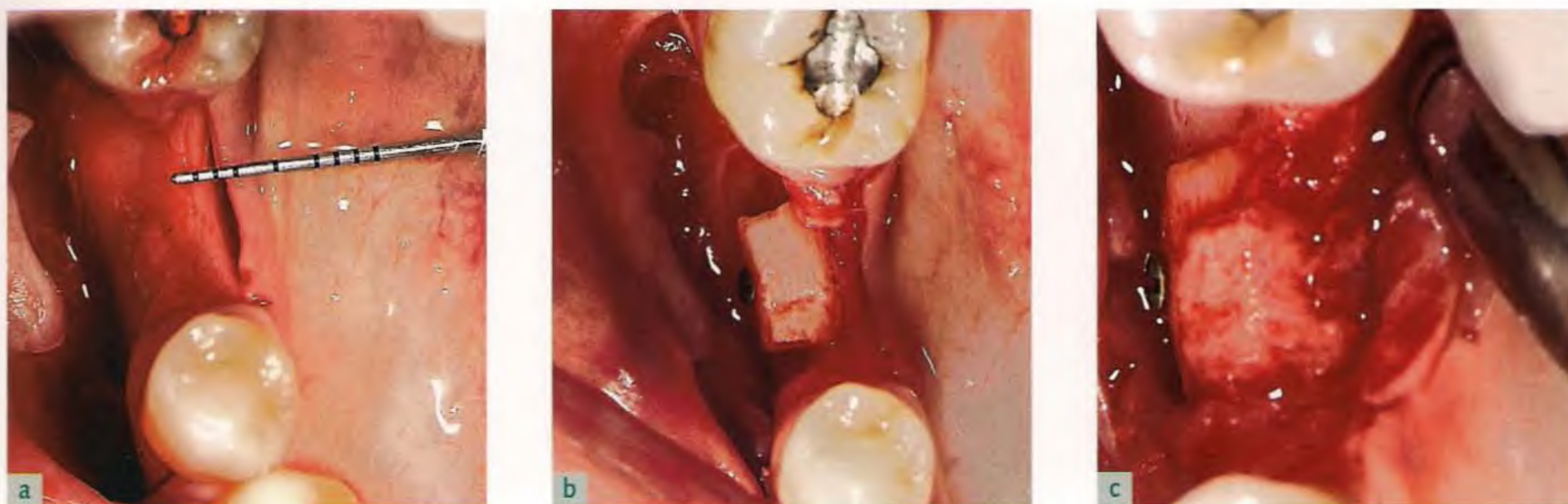


Fig 6-29 Augmentation of the crestal volume with an autograft. (a) Distinct buccolingual atrophy; (b) autograft bone section removed from the intraoral site and stabilized with transcortical screws; (c) healing of the graft after 6 months.

abundant than normally necessary to compensate for postsurgical contractions of the graft and to allow eventual modification of the profile of the crest by gingivoplasty after healing is complete.

For this procedure, the recipient site is measured, and then the palate or surrounding area is examined to determine if a sufficient quantity of donor tissue is available. Postsurgical contraction of 30%^{237,238} must be taken into consideration when the dimensions of the graft are determined, and the presence of a particularly thin palate could be a serious contraindication for this procedure.^{235,238-243} In a small number of cases, however, crests can have such large deformities that a simple mucogingival surgical intervention is not sufficient to eliminate the defect. To avoid the need to repeat the surgery a number of times, or in cases where it is not possible to find a sufficient quantity of intraoral soft tissues, it is possible to perform a submucosal graft of hard material, such as hydroxyapatite, calcium sulfate, and autologous and heterologous bone^{253,238,244-253} (Fig 6-29).

These procedures have the great advantage of not being limited to the availability of autologous grafting materials, but the success of the operation is strictly dependent on the experience and the skill of the surgeon and on an understanding of the changes that can occur in the grafted materials over time.

Mucogingival procedures to restore or increase the marginal gingiva

The need for an adequate strip of attached tissue^{222,254-261} in the marginal gingiva has been extensively discussed. Today it can be confirmed that periodontal health and stability of the marginal gingiva can be maintained even in the absence of attached gingiva, as long as no signs of periodontal disease are present and oral hygiene is adequate.^{222,254,260} However, there

are situations in which an increase in the gingiva is indicated for esthetic and functional reasons.

An unesthetic appearance or dental hypersensitivity caused by gingival recession is an indication for mucogingival surgery,²⁶²⁻²⁶⁶ as are juxtagingival abutment preparations in patients with gingivae that are particularly thin and mobile. Different surgical procedures can satisfy these needs; some, such as free gingival grafts and coronally repositioned flaps, are easier to carry out; others, such as double papilla flaps,^{267,268} oblique rotated flaps,²⁶⁹ lateral sliding flaps,²⁷⁰⁻²⁷⁵ and the bilaminar and regenerative techniques,^{276,277,278} are advisable only in expert hands.

Free gingival grafts

Among mucogingival surgical techniques, free grafts are historically the first²⁷⁹⁻²⁸² and are used both to provide coverage for the roots and to increase the quantity of attached gingiva. Various procedures have been proposed.²⁸³⁻²⁹⁰ The simplest procedure is carried out by delimiting the receiving site with a partial-thickness flap, positioned apical to the mucogingival line, to create a periosteal bed.²⁹¹⁻²⁹³ In cases where root coverage is desired, the surface to be covered has to be scaled and planed thoroughly, so that the necrotic cementum is removed and convexities are eliminated as much as possible to make the adaptation of the graft as easy as possible. The donor graft, which must have a thickness of at least 1.5 to 2.0 mm, is taken from the palate^{237,283} and can consist of both epithelium and connective tissue or just connective tissue. Harvesting a graft of both epithelium and connective tissue is easier (Fig 6-30), and grafts of greater thickness are obtained; for this reason it is recommended in the palatal area with limited thickness or with a thickness of less than 4 to 5 mm. The disadvantage of this tech-

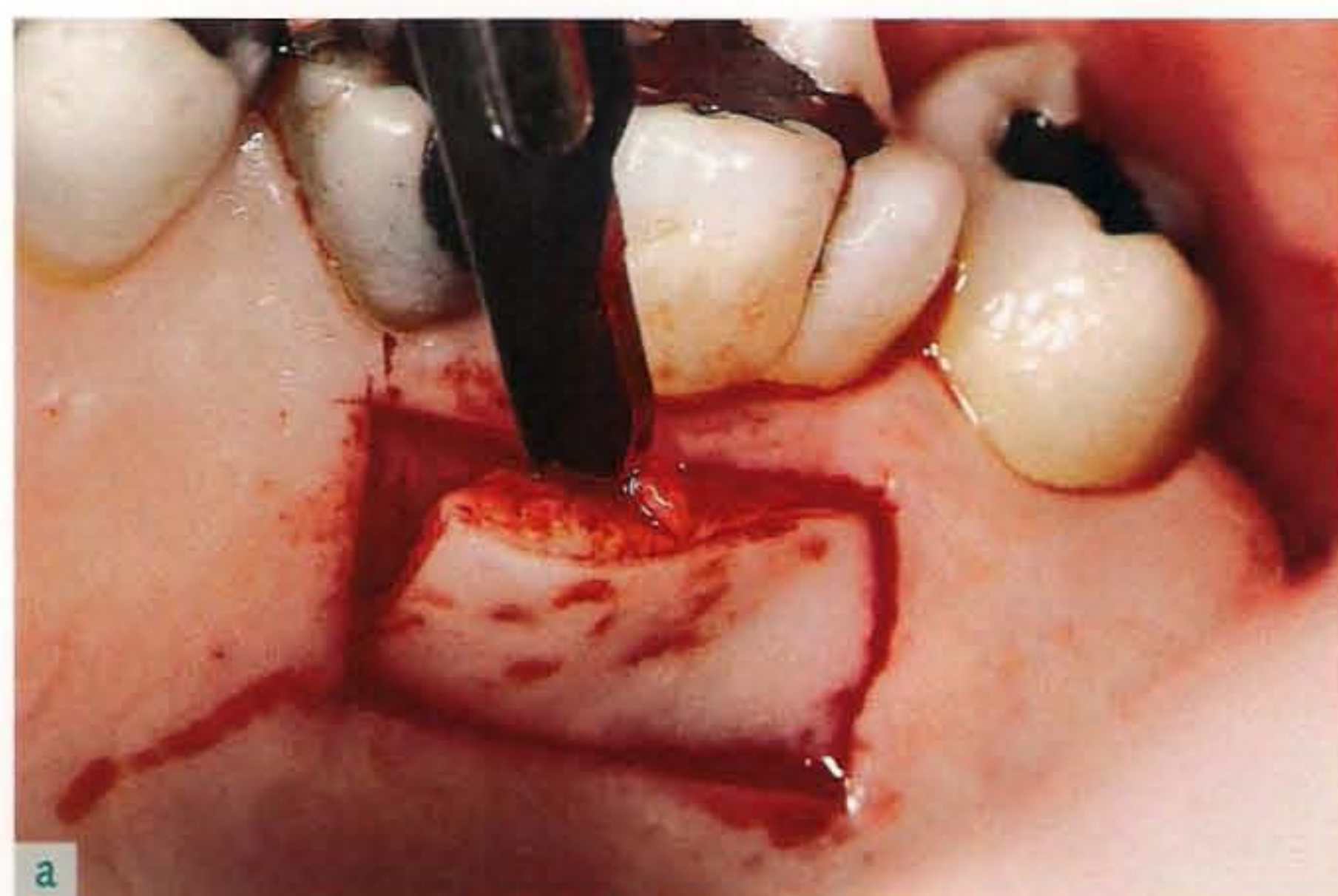


Fig 6-30 (a) Removal of the epithelial connective tissue graft from the palatal area; (b) donor site after removal of the graft.

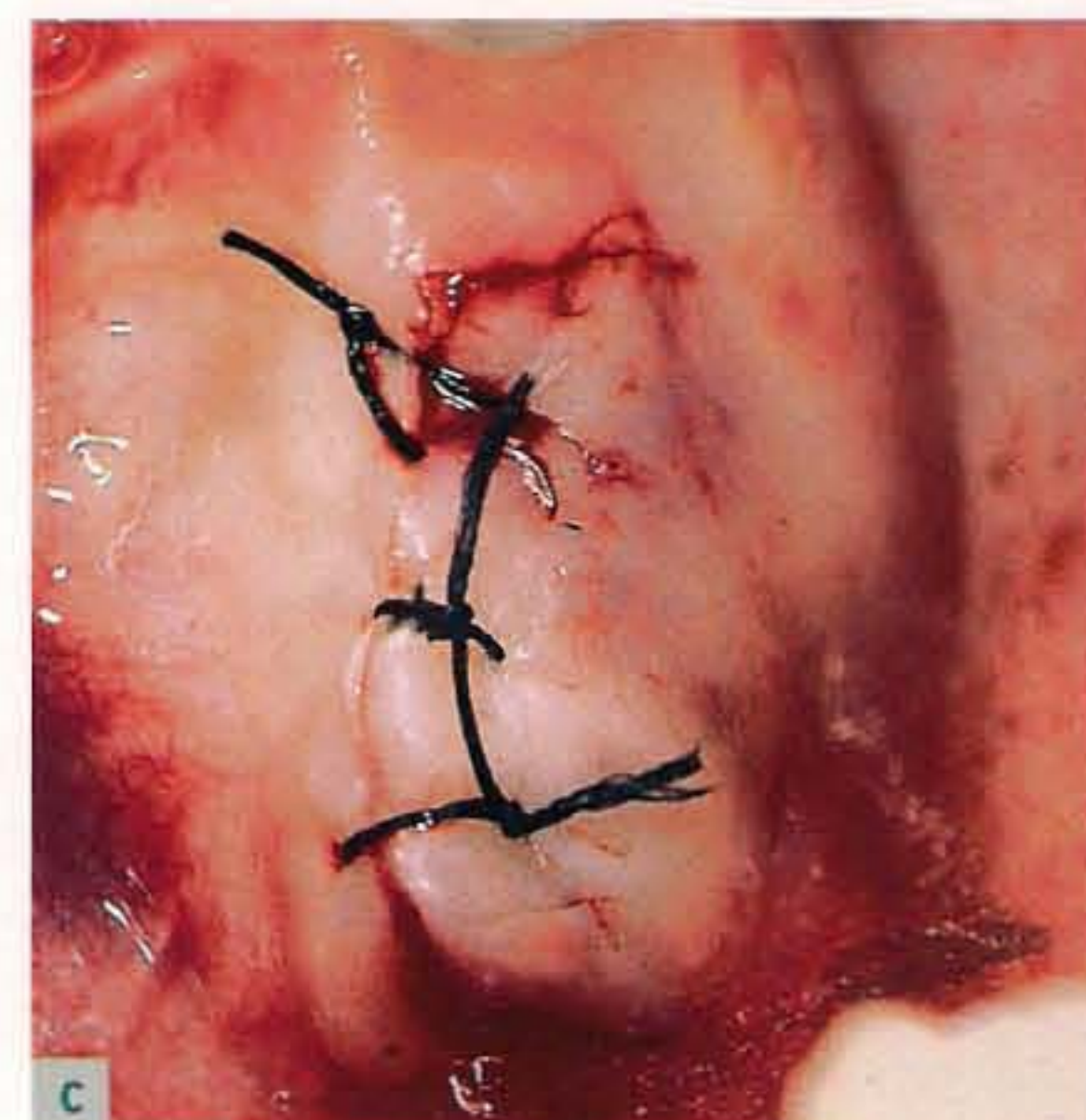
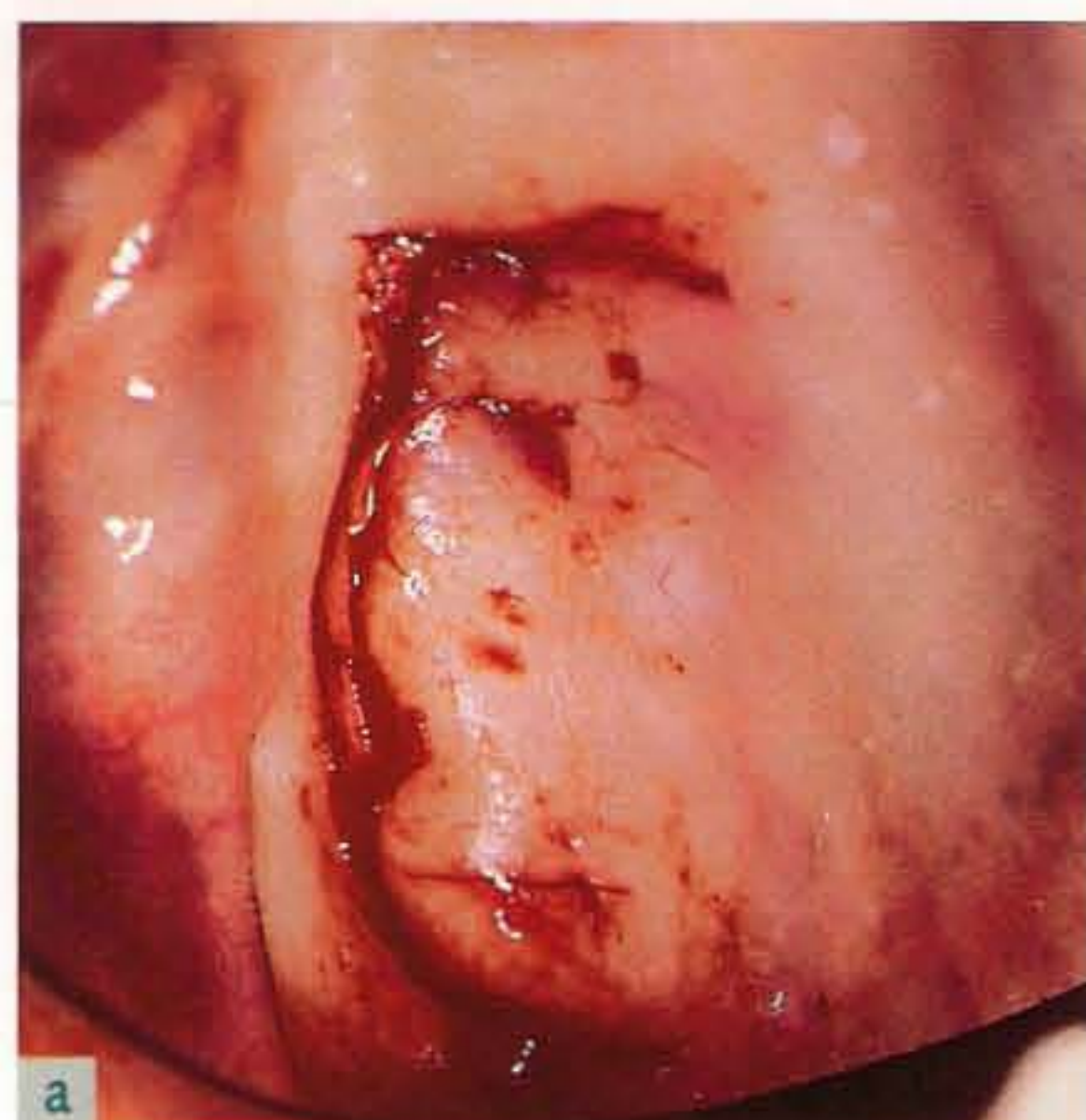


Fig 6-31 (a to c) Trapdoor technique for harvesting of graft tissue.

nique is the discomfort experienced by the patient because of the healing by secondary intention of the site from which the specimen is taken.

The connective tissue graft can be obtained by means of the trapdoor technique or by the envelope technique only when the thickness is greater than 4 to 5 mm; although it is more difficult to carry out, it has the advantage of a more comfortable healing process in the palate. An area that easily offers these conditions is the area of the tuberosity (Fig 6-31).

The suture must immobilize the graft, creating an intimate contact with the recipient bed; this process is encouraged by compressing the graft with gauze for a few minutes once the suture is completed. A suture that is not well executed, and allows movement of the graft when stimulated, can result in partial or total necrosis, which hinders treatment. The suture is removed after 8 to 10 days (Fig 6-32).

In the past, the usefulness of conditioning the root surface with acidic substances such as citric acid or tetracycline

hydrochloride after scaling and root planing was discussed extensively.²⁹⁴⁻²⁹⁹ The aim of this procedure is the removal of the smear layer and the exposure of the dentinal collagen, stimulating the adhesion of the fibroblasts coming from the graft. The usefulness of this procedure has come into question.

Subepithelial connective tissue grafts: The envelope technique

This technique to cover exposed roots and to increase gingival attachment was described for the first time by Raetzke³⁰⁰ in 1985 and later modified by others.^{301,302} This graft, like all connective tissue grafts, is inserted under the epithelium. The procedure has as its primary advantage the optimization of blood flow to the graft, reducing the risk of secondary necrosis to a minimum.

A sulcular incision is carried out on the buccal surface of the tooth to be treated, and the interproximal papillae are partially undermined with a blade but not raised. The incision is deep-

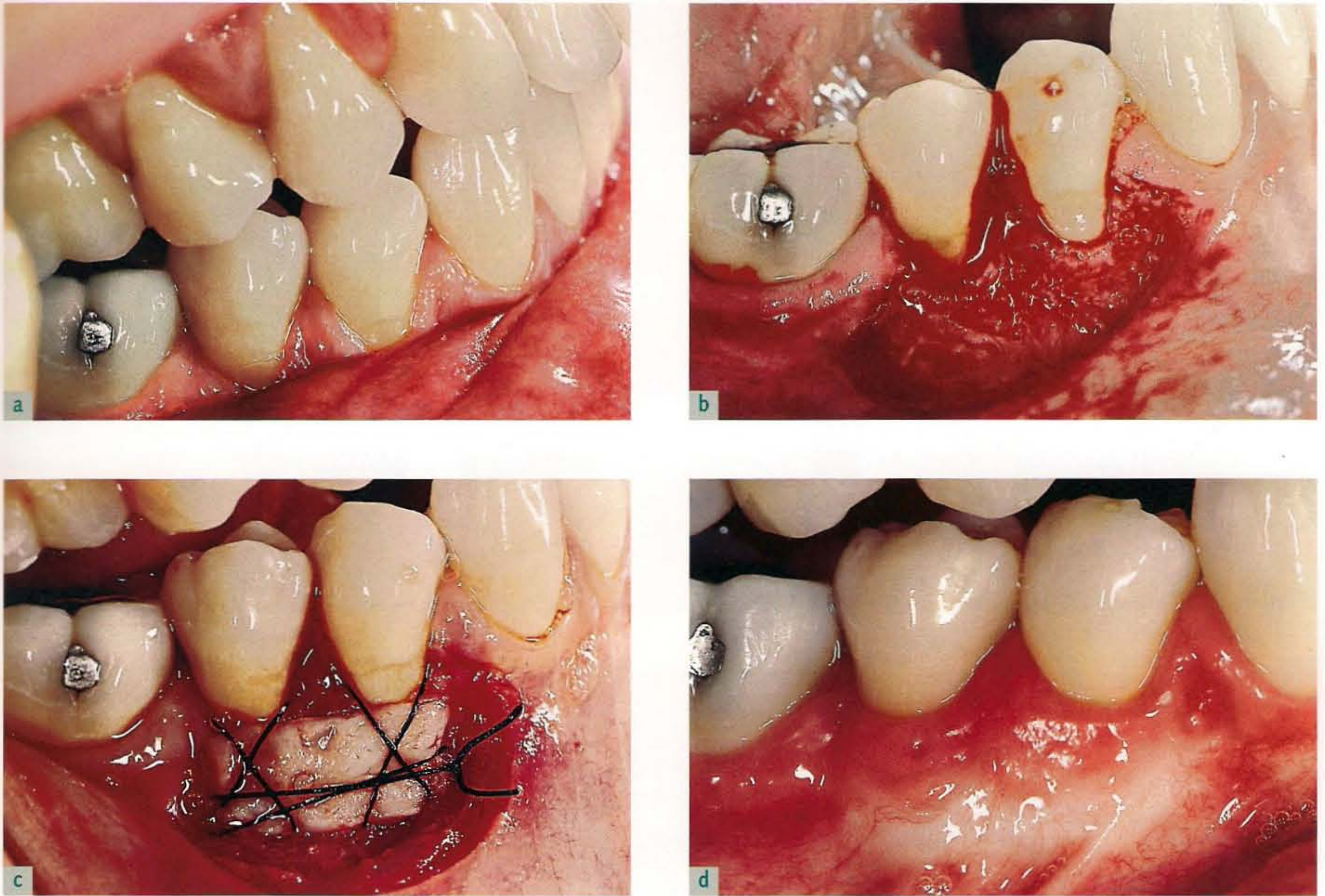


Fig 6-32 Free gingival graft. (a) Preoperative view showing the absence of keratinized gingiva and the vestibular fornix; (b) preparation of the graft recipient site; (c) sutured connective tissue graft; (d) healing after 12 months.

ened to partial thickness until an envelope of the required dimensions is obtained; the graft must be at least twice the dimensions of the recession to be recovered. The root surface is accurately planed and flattened; some authors suggest conditioning with citric acid or tetracycline hydrochloride in this case as well.

The connective tissue is harvested from the palatal site as already described, inserted in the pocket, and carefully sutured in position to the periosteum or to the surrounding connective tissue. The esthetic and functional results are usually good.

Coronally repositioned flaps

Coronally repositioned flaps³⁰³⁻³⁰⁷ are recommended when is not necessary to increase the keratinization of the gingiva that is present but when the aim is to simply correct a gingival recession.

A sulcular vestibular incision that extends horizontally, preserving the adjacent papillae, is made. Two vertical incisions fol-

low, starting from the distal aspect of the base of the mesial and distal papillae. The flap is lifted to partial thickness as previously described, and, after the epithelium is removed from the buccal surface of the papillae, the coronal flap is repositioned. The flap is sutured into position with interrupted sutures both along the buccal incisions and in correspondence with the interproximal zone.

This flap can also be combined with a connective tissue graft in a case in which the recession is particularly large and deep; the coronal repositioning increases the blood supply to the graft on the nonvascular surface of the root that is to be covered. The use of a connective tissue graft interposed between the radicular surface and the primary repositioned flap (bilaminar technique) improves the result, especially in the presence of a large recession (Fig 6-33).

The root coverage achieved is strictly linked to the extent of the recession and to the conditions of the adjacent periodontal tissues^{283,308-310}; recessions that extend beyond the mucogin-

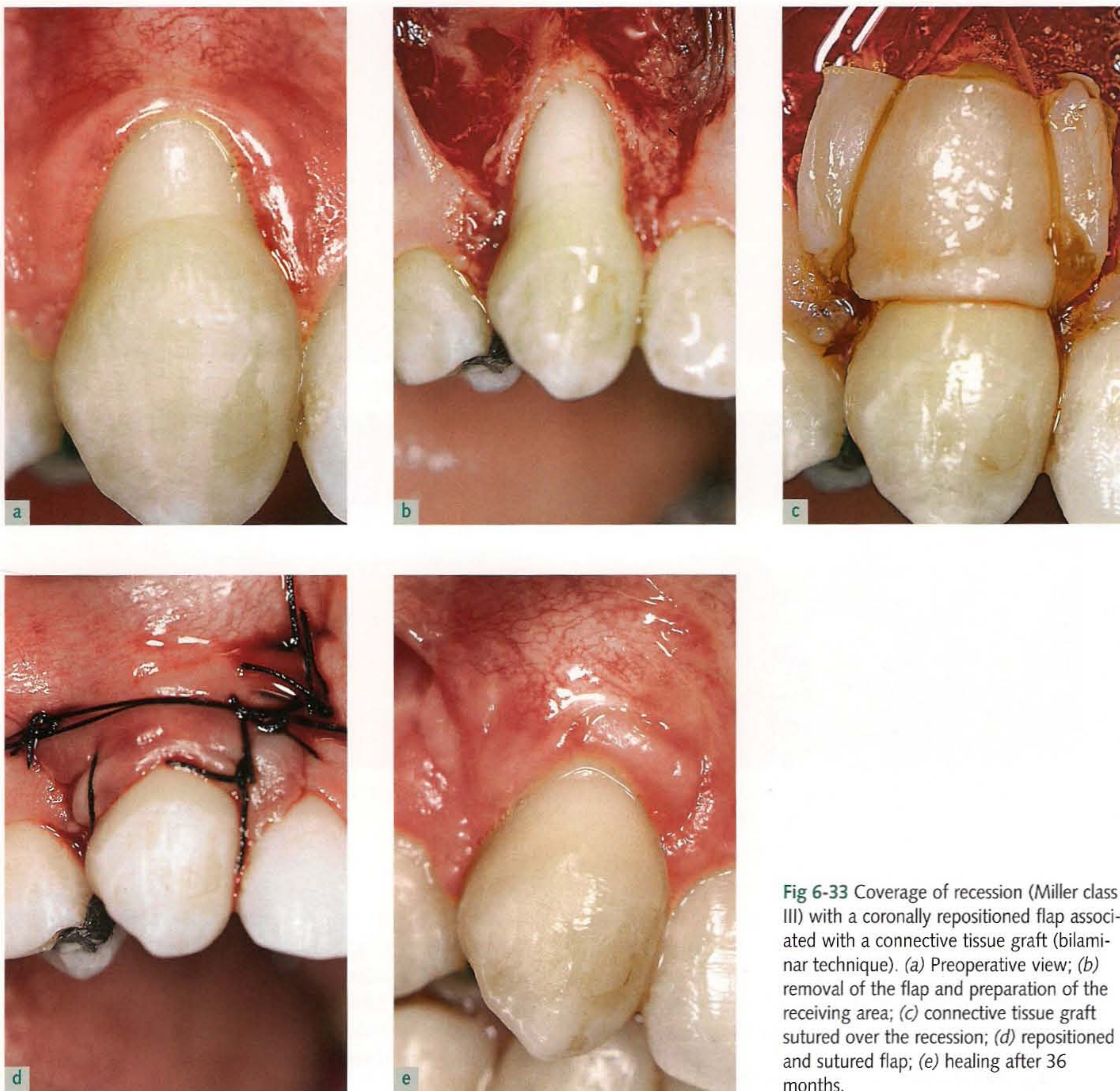


Fig 6-33 Coverage of recession (Miller class III) with a coronally repositioned flap associated with a connective tissue graft (bilaminar technique). (a) Preoperative view; (b) removal of the flap and preparation of the receiving area; (c) connective tissue graft sutured over the recession; (d) repositioned and sutured flap; (e) healing after 36 months.

gival line and that are not associated with loss of bony or soft tissue in the interdental area can be covered completely. If a loss of interproximal periodontal tissues is associated with root exposure, the coverage obtained will be partial.

Poor oral hygiene and smoking represent serious contraindications to mucogingival therapy.³¹¹

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7

Preprosthetic Orthodontics and Segmental Osteotomy

Preprosthetic Orthodontics

As complementary treatment to prosthetic rehabilitation, dental orthopedics aims to improve certain aspects of occlusion rather than completely modify it, which simplifies the treatment plan, thereby resolving the case in the most conservative way. Orthodontic therapy must be as brief as possible, have specific aims, and be correctly timed as an integral part of a multidisciplinary treatment.^{1,2}

Indications and contraindications

Through orthodontic treatment it is possible to:

- Avoid prostheses, closing the spaces present when a single tooth is congenitally missing or missing as a result of extraction.
- Simplify prosthetic replacement of a single malpositioned tooth that could create unfavorable periodontal situations, incorrect points of contact, or esthetic problems.
- Correct misalignment between abutment teeth, a situation that makes preparation of a replacement tooth difficult and would cause damage to bone because of transmission of nonaxial forces.
- Eliminate excessive buccal or lingual tooth angulation, especially in the maxilla, which could cause esthetic and functional problems.
- Redistribute the edentulous spaces, where necessary, to allow a better esthetic result or a more favorable division of the masticatory load (eg, in edentulous areas that are too extensive).
- Optimize the occlusal plan by leveling of the arch.
- Reduce the level of deep bite when, because of extensive tooth loss in the posterior area, the vertical dimension of occlusion has collapsed to such a degree that a high-quality prosthetic rehabilitation would be impossible.

Furthermore, orthodontic treatment is a useful way of improving the prognosis of compromised periodontal conditions,^{3,4}

thanks to the histologic effects provoked by the orthodontic movements (Boxes 7-1 and 7-2).

Box 7-1 Objectives of preprosthetic orthodontic treatment

Slow extrusion

- Treatment of one- or two-wall defects
- Treatment of circumferential defects
- Reduction of infrabony pockets
- Correction of gingival profiles

Rapid extrusion

- Superficialization of deep caries lesions
- Treatment of root fractures (coronal third of the root)
- Correction of reduced clinical crown heights
- Treatment of root perforations
- In these cases of extrusive movement, gingival fibrotomy interventions every 2 weeks

Intrusion

- Compensation for horizontal bone loss
- Reduction of infrabony pockets
- Increase of probing depths
- Increase of clinical crown lengths
- Leveling of incisal margins

Molar uprighting

- Elimination of functional interferences
- Correction of occlusal trauma
- Uprighting of abutment teeth that are not parallel
- Creation of spaces for the placement of implants
- *Mesiodistal movements*
- Distribution of abutment teeth as agreed with the prosthodontist

Box 7-2 Tissue responses to orthodontic movements

- The movement of teeth as a result of application of orthodontic forces is accompanied by histologic modifications of the osseous tissues and the periodontal ligaments. There are two main theories to explain the bone remodeling caused by forces applied to the teeth. The piezoelectric theory⁵ is validated by biologic electrolytic signals that induce modifications in the polarity of cellular membranes, the phenomenon of resorption that increases in the positively charged areas, and the phenomenon of apposition in the negatively charged areas.^{6,7}
- The second theory considers the variation of the blood flow because of phenomena of pressure and traction inside the periodontal ligament. Such variation in flow⁸ and the consequent tension and pressure on the periodontal ligament determines variations in the percentage of oxygen, with resulting release of chemical mediators such as prostaglandin,⁹ cytokines, and cyclic adenosine monophosphate, thereby inducing activation of specialized cells, such as osteoclasts and osteoblasts, and remodeling of the bone (resorption and apposition).
- The orthodontic forces used to obtain dental movement in a reasonable time must be light (less than 200 g), to induce the aforementioned metabolic modifications. In these cases, direct resorption is obtained with the almost immediate appearance, in the lamina dura, of osteoclasts in the area under pressure and of new bone in the area under traction (Fig 7-1).
- If larger forces (greater than 300 g) are used, they induce occlusion of the blood vessels in the periodontal ligament and disappearance of the cellular component; as a result, the periodontal fibers assume a hyalin and glassy appearance (hyalinization). The osteoclasts appear in the medullary space below and are subjected to minor pressure that causes bone resorption of an indirect or undermining type. The zone of hyalinization then delays the response to tooth movement until the osteoclasts have attained the lamina dura, in about 2 to 3 weeks.

The clinician who is planning preprosthetic orthodontic therapy must consider the motivation, periodontal conditions, and general state of health of the patient. A serious periodontal situation can result in esthetic problems that cause the patient to undertake orthodontic treatment.

Improving the position of the teeth benefits subsequent restorative interventions. Motivation, attained by the providing good information to the patient and thereby increasing collabor-

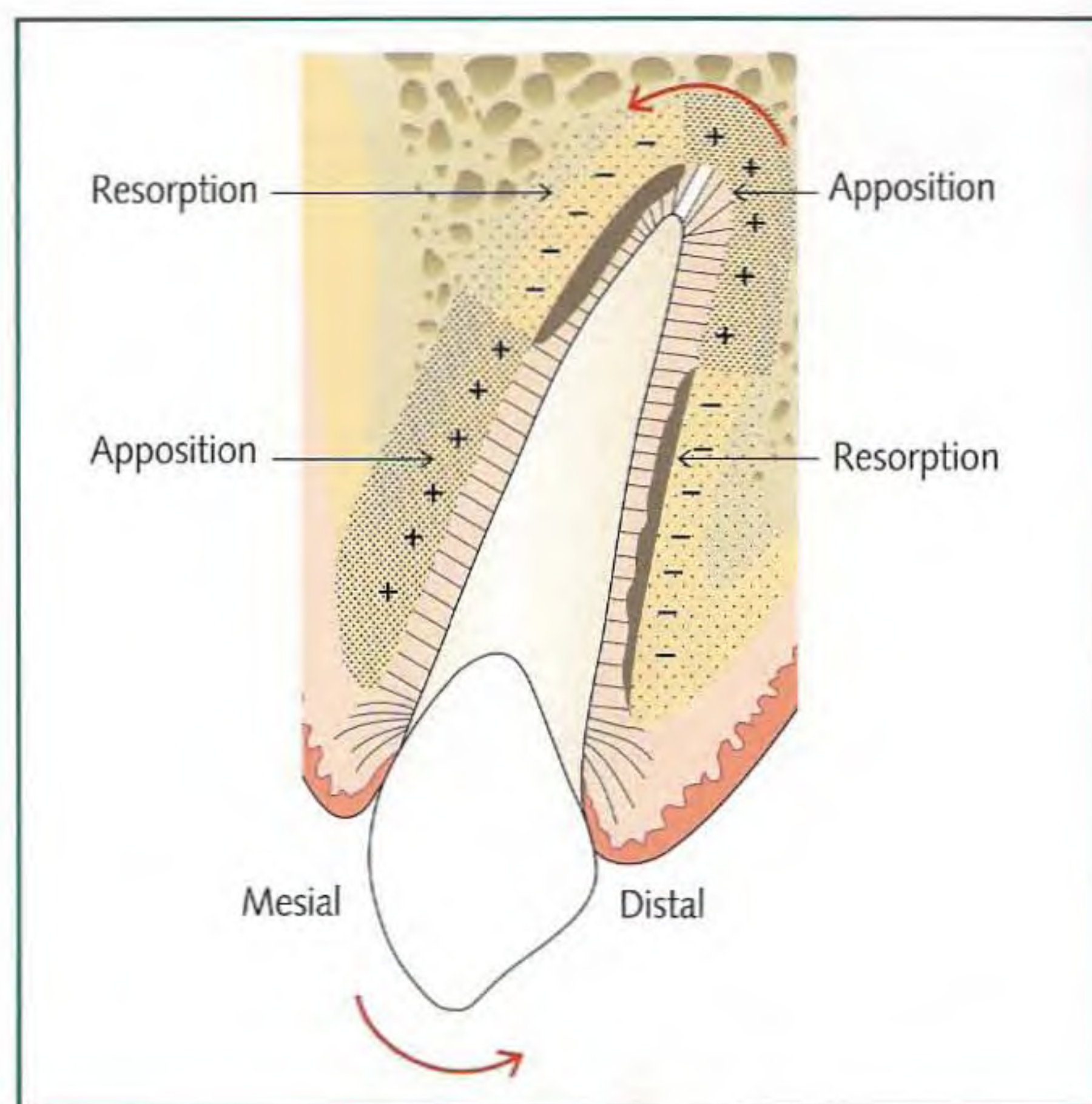


Fig 7-1 An orthodontic force applied to a tooth provokes resorption in the area under pressure and apposition in the area undergoing traction.

ation, is an important element for reaching the objectives.¹⁰ The period of preparation also allows evaluation of the level of patient cooperation as well as the reaction of the tissues to periodontal treatment. It has been widely proved in literature that all types of orthodontic movement must be carried out in the presence of a healthy, even if reduced, periodontium.^{7,8,11} Any type of orthodontic force applied in the presence of inflammation provokes the rapid progression into severe periodontal disease.

It is necessary to evaluate the biologic and economic costs involved in orthodontic treatment: the possibility of relapse; the collateral effects on the adjacent teeth; the influence on the duration of the treatment; and the economic implications. It is important to consider, in depth, the general health of the patient and the psychological impact that such a treatment will have.¹² Chronic illnesses, such as cardiovascular disease, diabetes, disturbances of the immune system, collagenous diseases, or radiation therapy, may necessitate different plans of therapy (see chapter 2). In these cases, it may be preferable to reduce the length of the therapy, for example, by extracting a malpositioned tooth instead of providing orthodontic treatment.

Adult patients who request or who are willing to accept orthodontic treatment can have unrealistic expectations. It is therefore essential to spend time explaining and clarifying the situation so that the final result, which may be considered

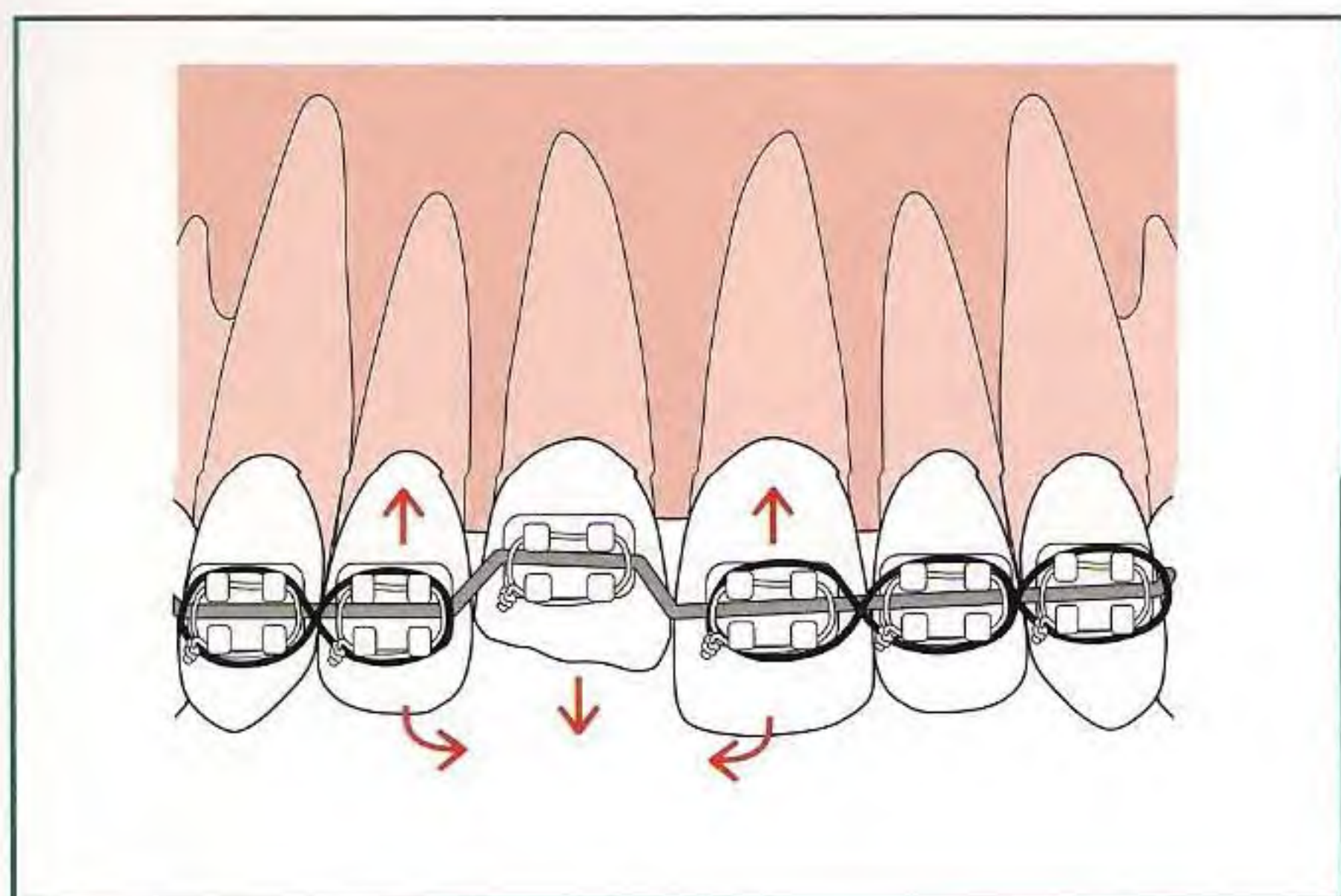


Fig 7-2 The attachment is located in a more apical position on the tooth to be extruded, and a continuous superelastic archwire is placed on all teeth in the arch.

excellent by the dentist, is not disappointing or unsatisfactory for the patient.¹²

Treatment planning

Orthodontic treatment planning is based on an accurate history complemented by results of clinical examinations, radiographic examinations with cephalometric tracing, and, when necessary, other instrumental analyses. The following parameters must be evaluated:

- The functionality of the oral cavity apparatus
- The conditions of the teeth, with particular attention to periodontal health
- The type of swallowing
- The type of respiration

A multidisciplinary team discussion concerning clinical cases in need of both prosthetic and periodontal treatment is required. The aim of this collaboration is to choose the therapeutic plan that is most appropriate for the needs of the patient, giving precedence to endodontic, conservative, and periodontal interventions. It is useful to reevaluate, at the end of each phase, the appropriateness of continuing with the original therapeutic plan.

Objectives

Extrusion

Controlled extrusion is an excellent method of conserving teeth that would otherwise have a negative prognosis. The consequence of extrusive movement is to bring virulent bacterial flora

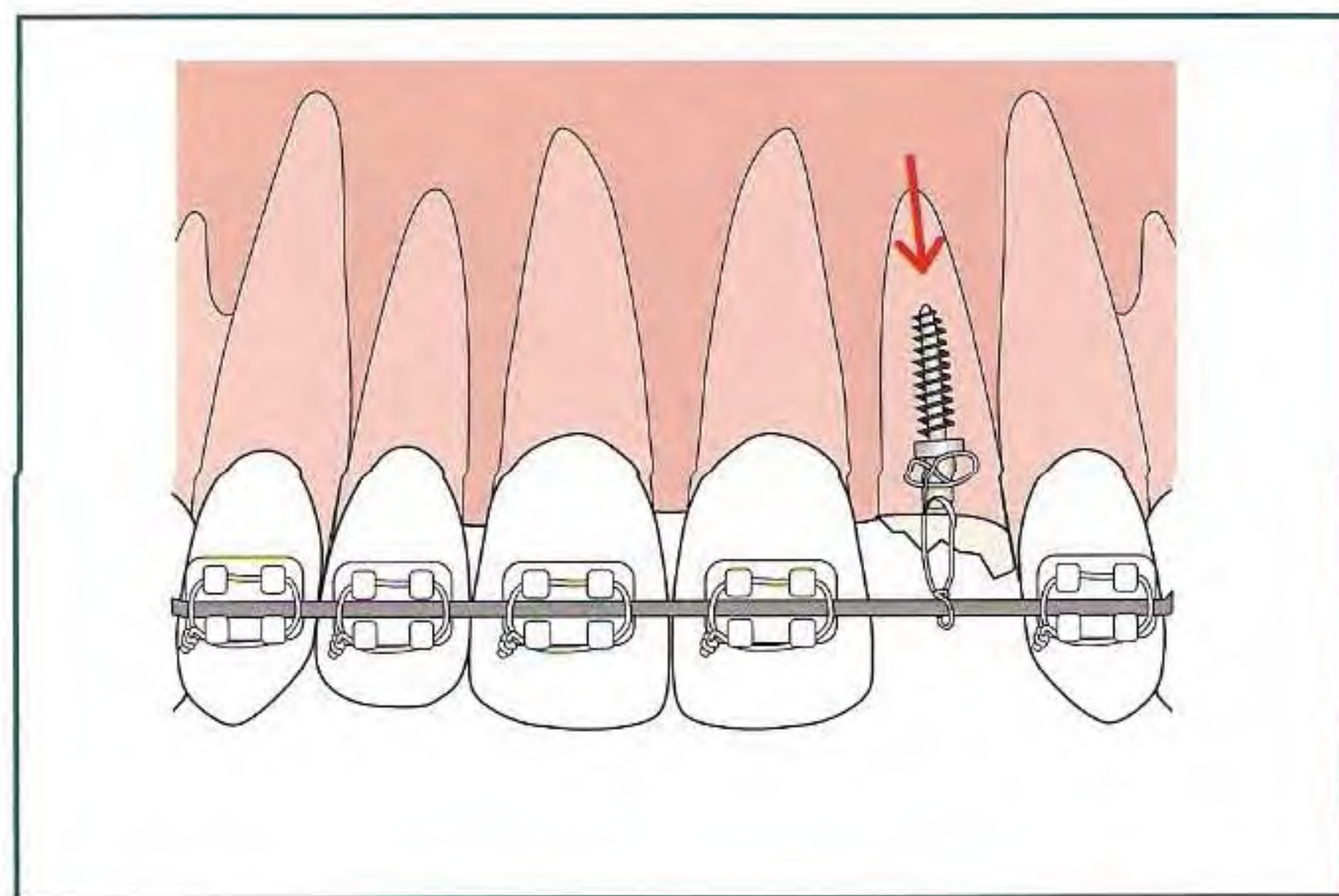


Fig 7-3 An intraradicular screw post is present in a maxillary lateral incisor with a lost crown. The elastic traction applied to the post from the fixed orthodontic appliance produces the extrusion.

to the surface.¹³ Generally, the prosthodontist uses extrusion to salvage a root or a tooth with a clinical crown that is insufficient for prosthetic repair. The periodontal conditions and the morphology of the roots influence treatment: Extrusion of teeth with ample and divergent roots is more problematic.^{3,16} Rare cases of hypercementation have been described in which it would be impossible to obtain movement.² The reaction to movement is the same for vital and nonvital teeth,¹⁷ and it is therefore possible to carry out endodontic treatment before or after the extrusion, according to the clinical needs.^{14,15}

To allow prosthetic restoration in the case of a localized root fracture at the height of the alveolar crest, the tooth should be extruded by about 3 mm; if the fracture is below the crest, the tooth should be extruded by about 5 mm.²

Appliances for extrusion

Extrusion is obtained with a fixed partial appliance. It is a movement that is simple enough to obtain, and therefore orthodontic intervention is not strictly necessary. If possible, a button or an eyelet is bonded directly to the abutment as a clasp for elastic traction. In other cases, it is better to place a provisional crown on which an attachment or orthodontic band is positioned more apically than the adjacent teeth. When a superelastic archwire is inserted at different levels of attachment, the tooth with the more apical attachment is extruded (Fig 7-2). At every examination, it is essential to remove any occlusal contacts of the provisional crown that may impede the vertical movement. If only one root is present, it is necessary to insert an endodontic screw post to which elastic traction can be attached (Fig 7-3).

The entire dental arch or just a segment can be used as anchorage for the therapy. The greater the number of teeth included in the fixed appliance, the better the control of the

forces, which must always be light and must not exceed 25 to 30 g per tooth.

The duration of orthodontic treatment varies depending on the age of the patient, the periodontal conditions, and the amount of movement needed. Movement of 1 mm a week can be obtained without damage to the periodontal ligament. Excessive forces can cause tissue damage or can lead to ankylosis of the tooth.

Retention

Once extrusion is achieved, it is useful to immobilize the tooth by attaching it to the adjacent teeth for a period of 3 to 6 weeks; in this way, correct physiologic regeneration of the tissues is allowed. At the end of treatment, it may be necessary to undertake plastic bone and gingival surgery.

Intrusion

Intrusion is a difficult movement to achieve and requires extensive knowledge of orthodontic techniques to avoid detrimental secondary effects that could lead to loss of one or more teeth. The use of excessive force can provoke root resorption or formation of infrabony pockets; incorrect anchorage could lead to extrusion of the adjacent teeth. It is advisable, therefore, to collaborate with an orthodontic specialist.

Intrusion is often needed before restorative therapy in the following cases:

- Increase of overjet and overbite to compensate for horizontal bone loss arising from maxillary incisor extrusion, proclination, or diastemas^{12,13,17,18}
- Extrusion of a tooth as a result of loss of the opposing tooth

It is possible to correct an extrusion that is no greater than 1 to 2 mm with orthodontics. For cases with a considerable level of extrusion, orthodontics is not advised; a periodontal-prosthetic solution should be chosen, or preprosthetic segmental surgery should be performed. Intrusive movement requires greater periodontal control to avoid the formation of deep infrabony pockets and the transformation of supragingival plaque to subgingival plaque, with possible increase of the virulence of the pathogens and consequent loss of attachment.

Melsen¹⁵ has shown that, once the infection has been eliminated in the patient affected by periodontal disease, it is possible to obtain a new attachment after moderate intrusion.

Appliances for intrusion

A fixed appliance that includes the entire involved arch is used for intrusion (Fig 7-4). The force should be no greater than 10 to 20 g per tooth, but correct calculation of the force is more difficult in the presence of periodontal problems because the center of resistance moves more apically and therefore further

away from the point of application of the force (Fig 7-5). The duration of treatment is from 4 to 8 months.

Retention

It is necessary to follow active treatment immediately with placement of a provisional fixed prosthesis or resin-bonded prosthesis for retention.

Molar uprighting

The need for molar uprighting is the most frequently encountered situation.¹⁷ The early loss of posterior teeth (most often first molars) results in inclination, migration, and rotation of adjacent teeth. Migration of the second molar is influenced by:

- The form and dimensions of the tooth.
- The amount of time passed since the loss of the first molar.
- The preexisting occlusion.
- The maxillofacial skeletal type of the patient.
- The age of the patient.
- The structure of the masticatory muscles.

The loss of the first molars is followed by distal inclination of the teeth mesial to the edentulous area, resulting in the opening of spaces in the rest of the arch. The extrusion of the opposing tooth often adds to this situation (Fig 7-6).

When planning uprighting in a dentition that includes the third molar, the clinician must evaluate whether it is preferable to proceed to straightening or to extraction. Indications for extraction of the third molar are the likelihood that it will hinder adequate hygiene and the possibility that it will introduce occlusal interference.¹⁷

Uprighting can be achieved by distalization of the crown (Fig 7-7); mesialization of the roots (Fig 7-8); or mesialization of the crown (Fig 7-9).

The first two movements maintain or increase the interdental space, while the third results in complete or almost complete closure of the space. Distalization of the teeth results in a reduction in the depth of the mesial pseudopocket (the attached gingiva follows the cemento-enamel junction, while the mucogingival junction remains unaltered).²

In the clinical evaluation, the clinician must consider whether slight extrusion of the moved teeth is acceptable, because this is the collateral effect of uprighting.

Appliances for uprighting

Uprighting is generally obtained with a fixed appliance that allows control of the root movement, which can consist of:

- Movement of the roots in a mesial direction while the crown is repositioned distally, if it is necessary to reestablish the exact preextraction space.

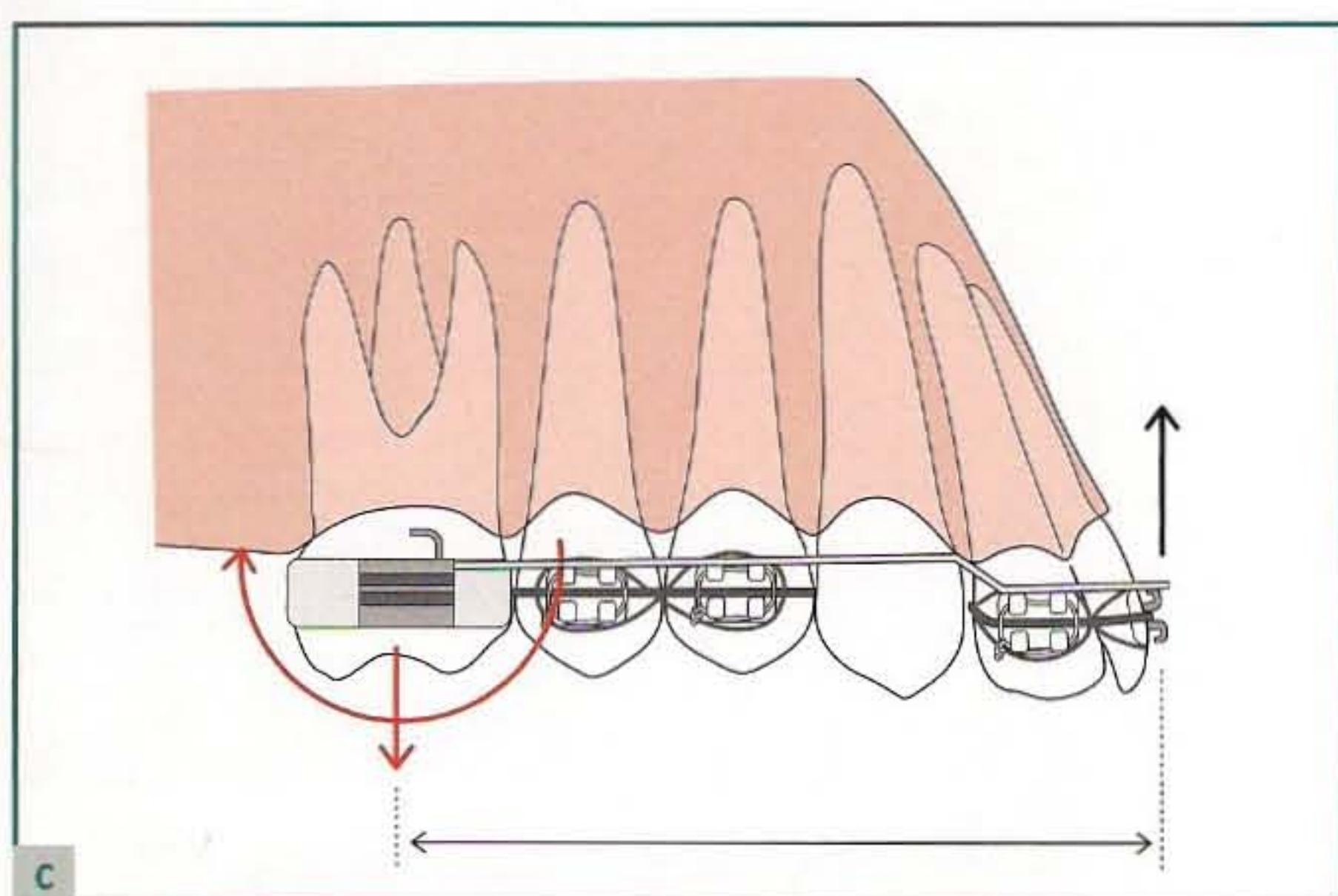
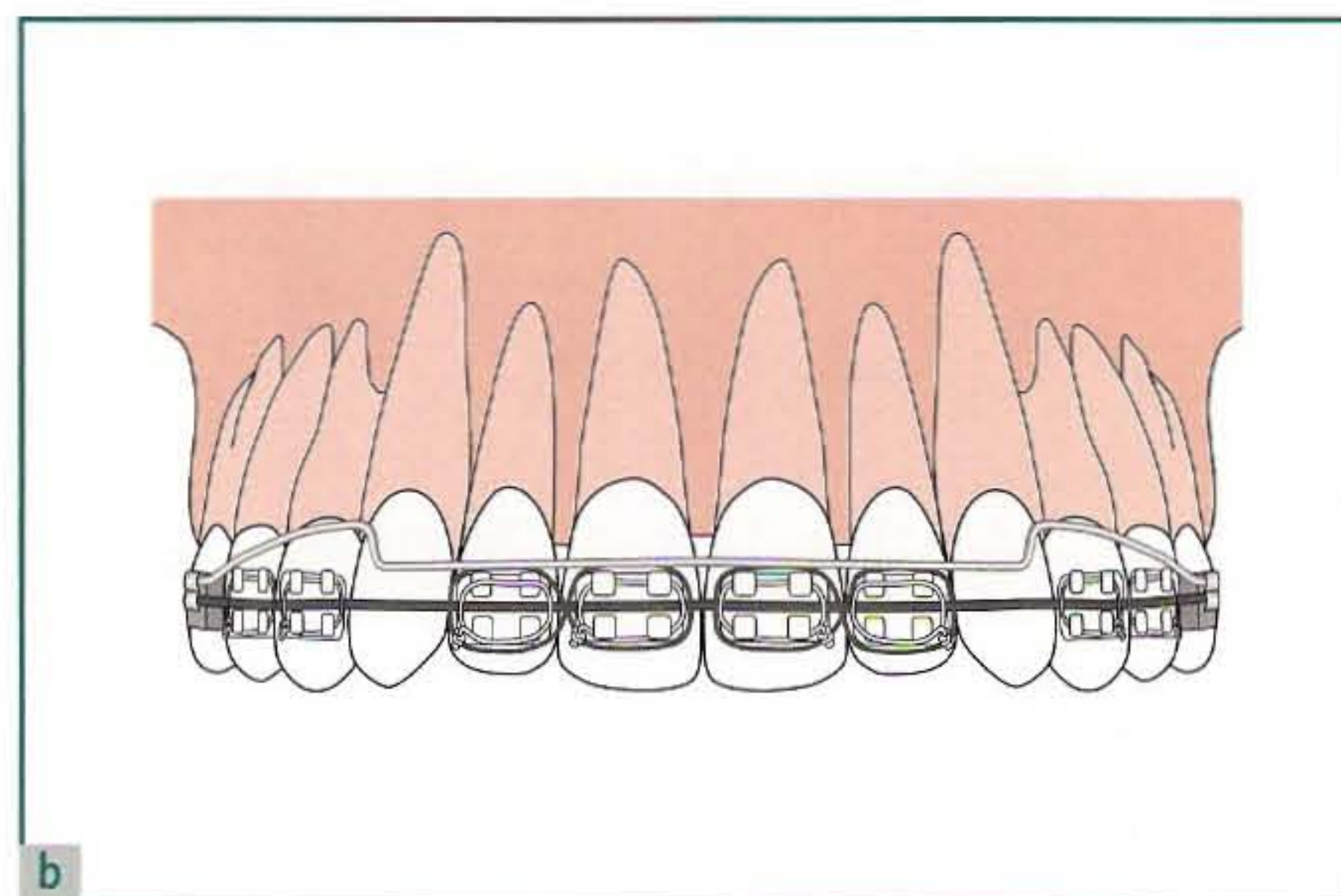
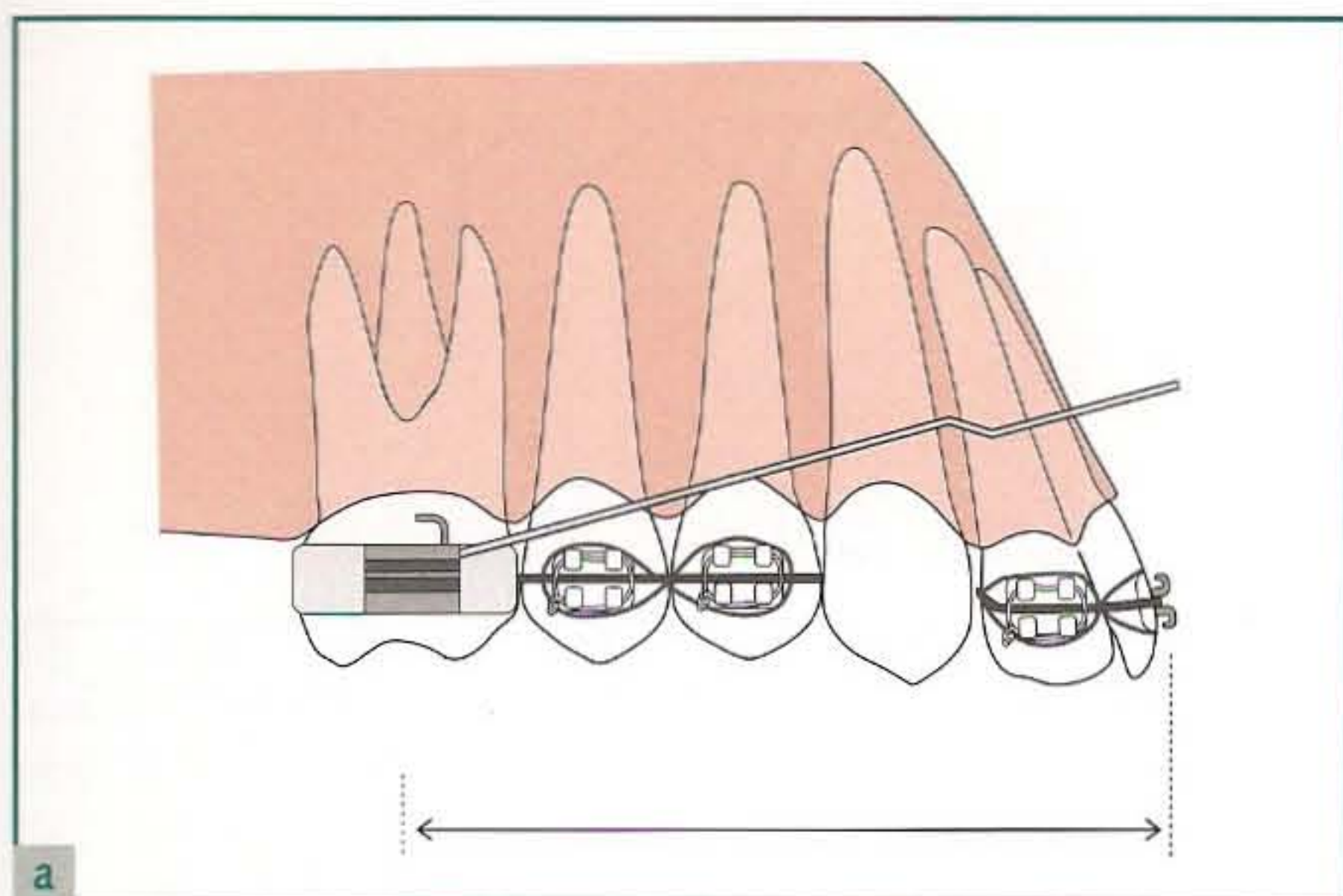


Fig 7-4 (a) An inactivated intrusion archwire is attached to the maxillary anterior segment; (b) the maxillary intrusion archwire is activated (frontal view); (c) the maxillary intrusion archwire is tied to the anchoring archwire and consequently active (lateral view).

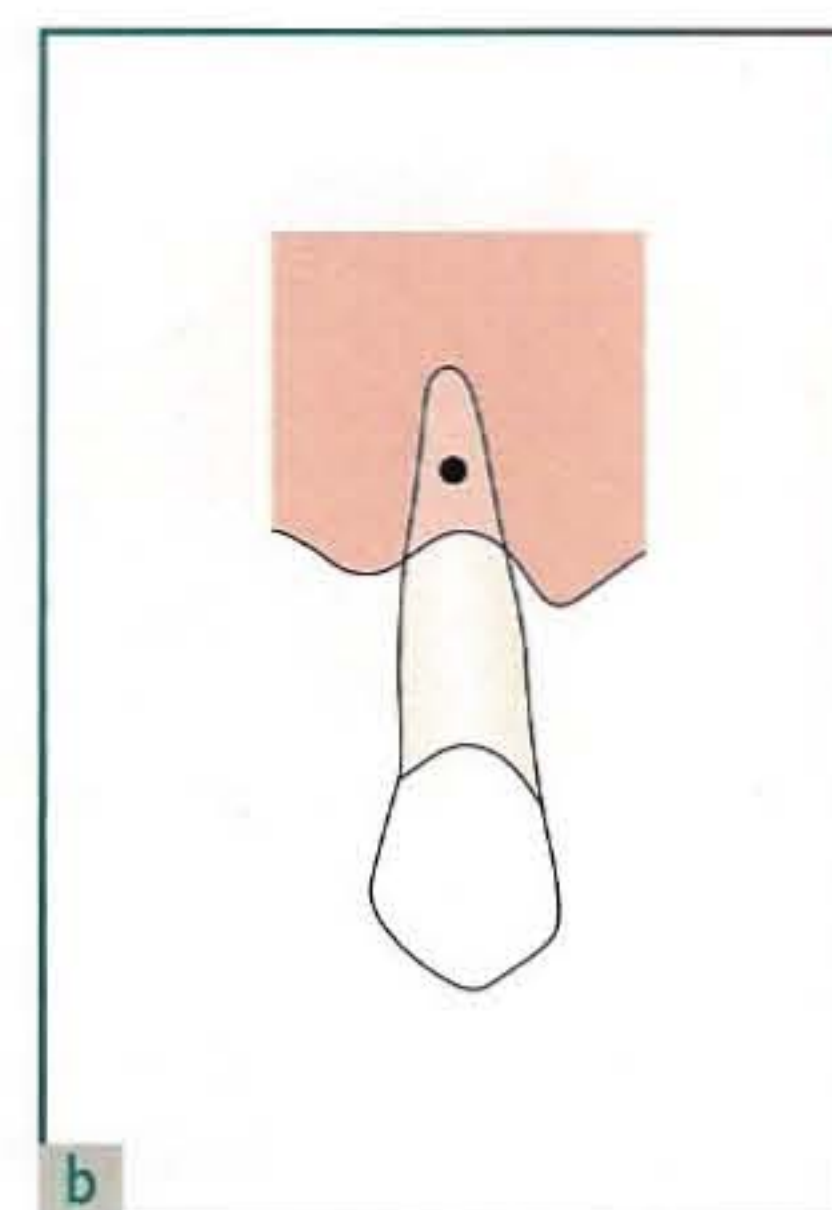
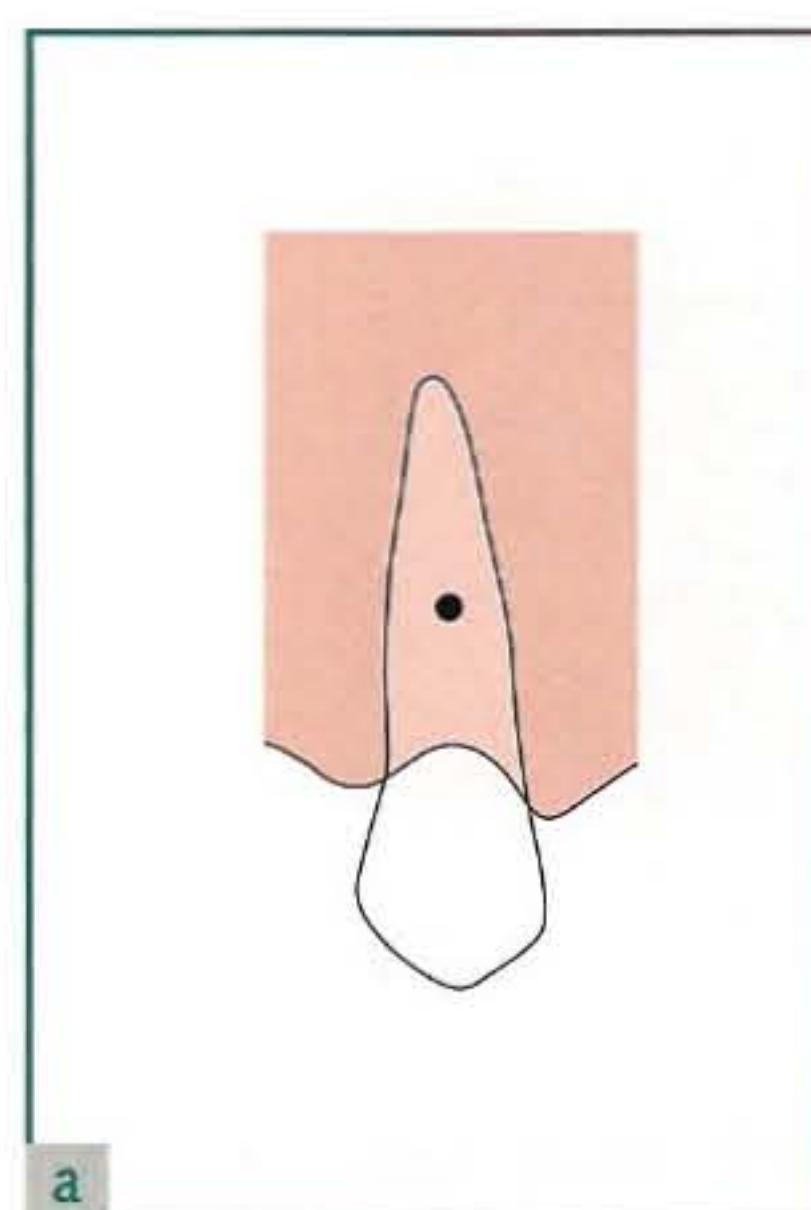


Fig 7-5 (a) In a patient who has no periodontal problems, the center of resistance of a single-rooted tooth is at the halfway point of the root; (b) in a patient with periodontitis, in whom a reduced portion of the root is intra-alveolar, the center of resistance is still situated at the halfway point of the intra-alveolar component of the root.



Fig 7-6 The maxillary molar is extruded as a result of the premature loss of the opposing tooth.

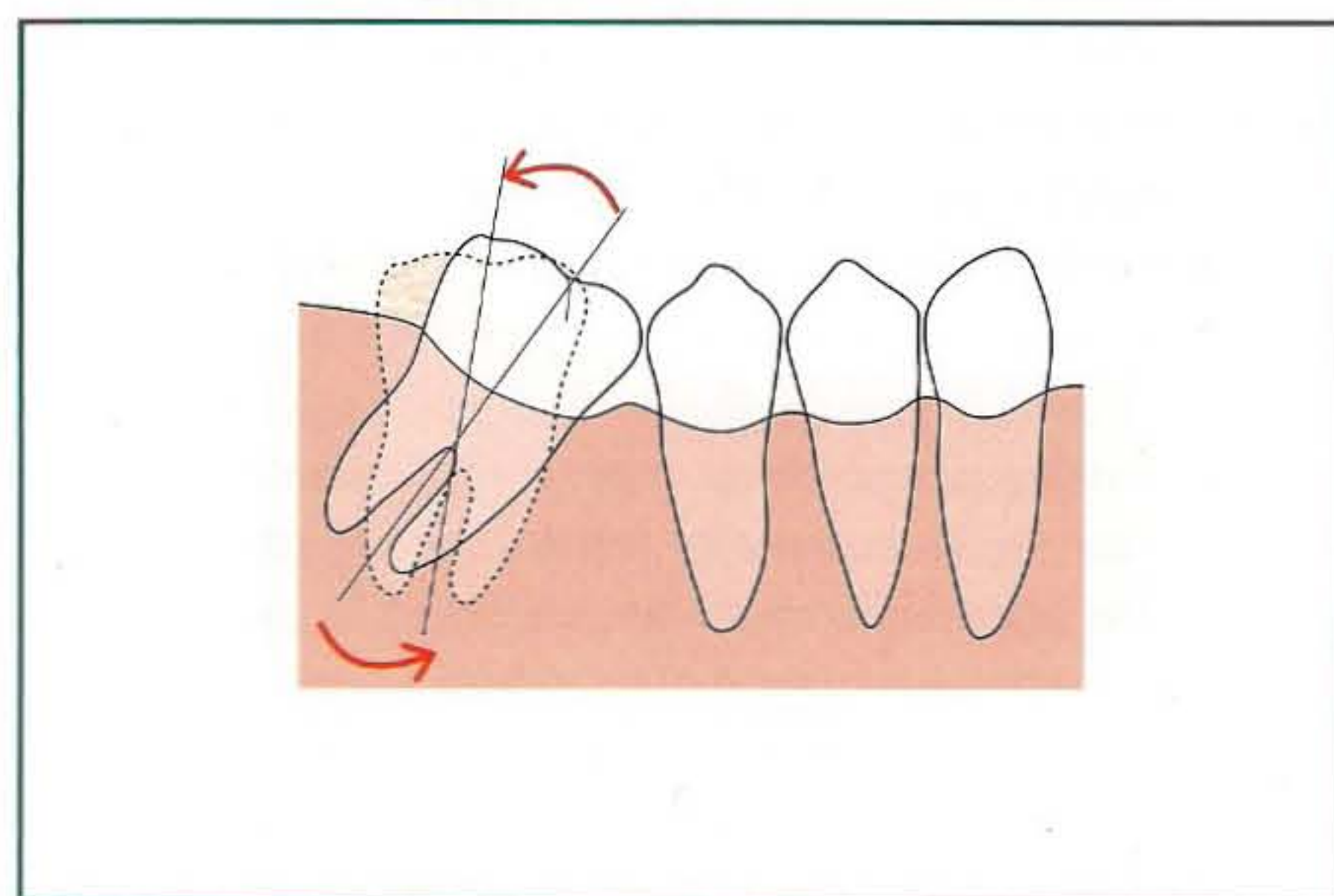


Fig 7-7 Uprighting movement of a molar through distalization of the crown.

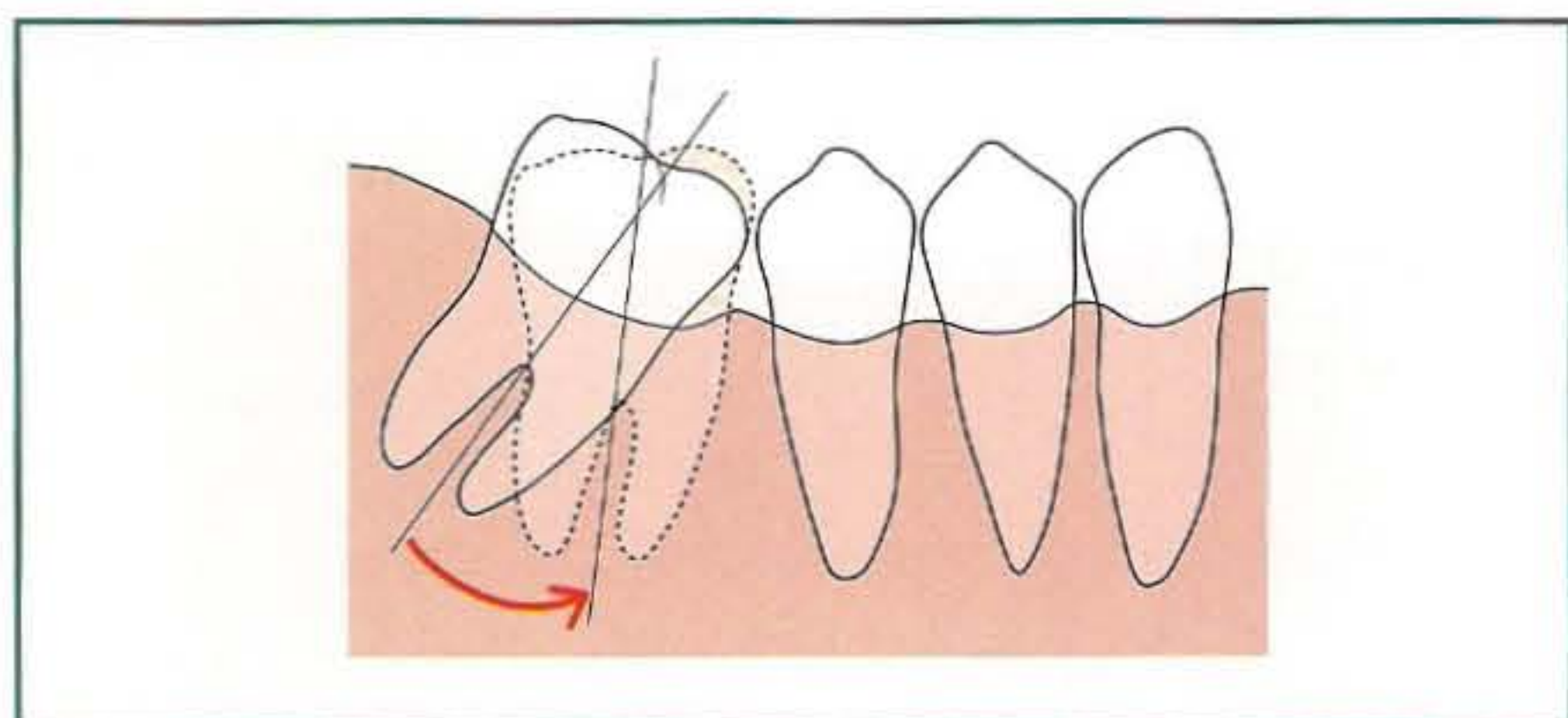


Fig 7-8 Uprighting movement of a molar through mesialization of the root.

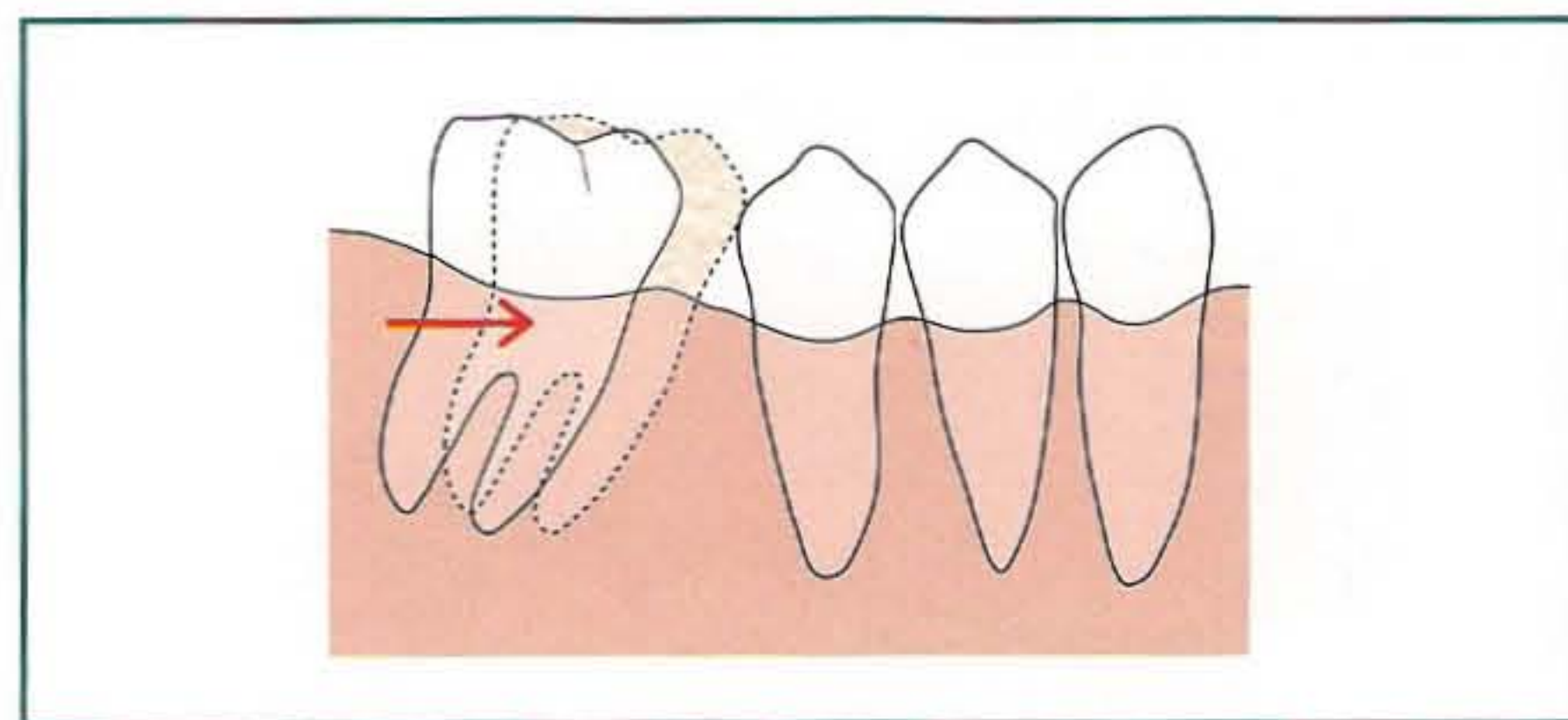


Fig 7-9 Uprighting movement of a molar through mesialization of the crown.

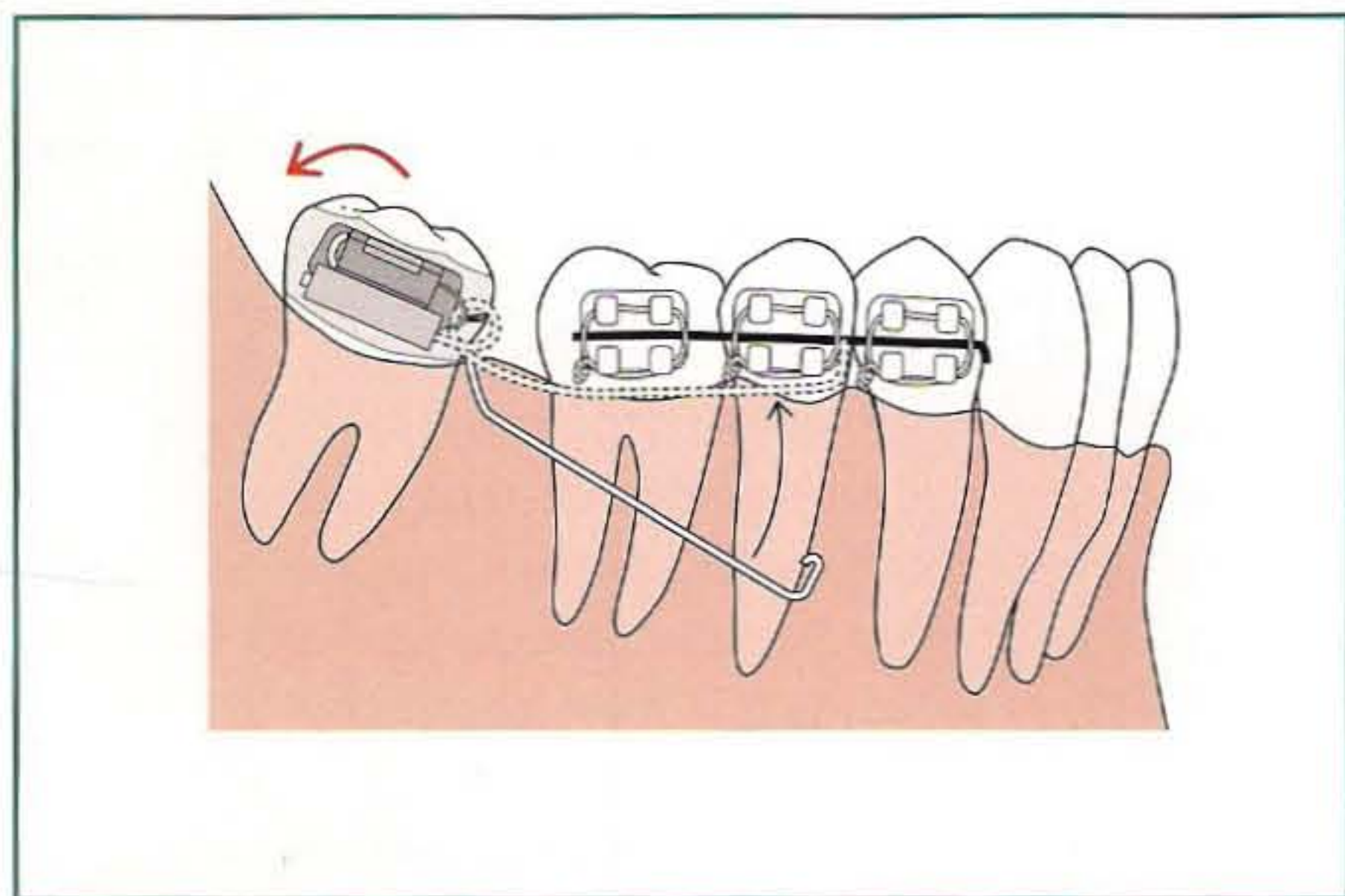


Fig 7-10 The inactive uprighting spring becomes activated when it is inserted in the anchorage unit.

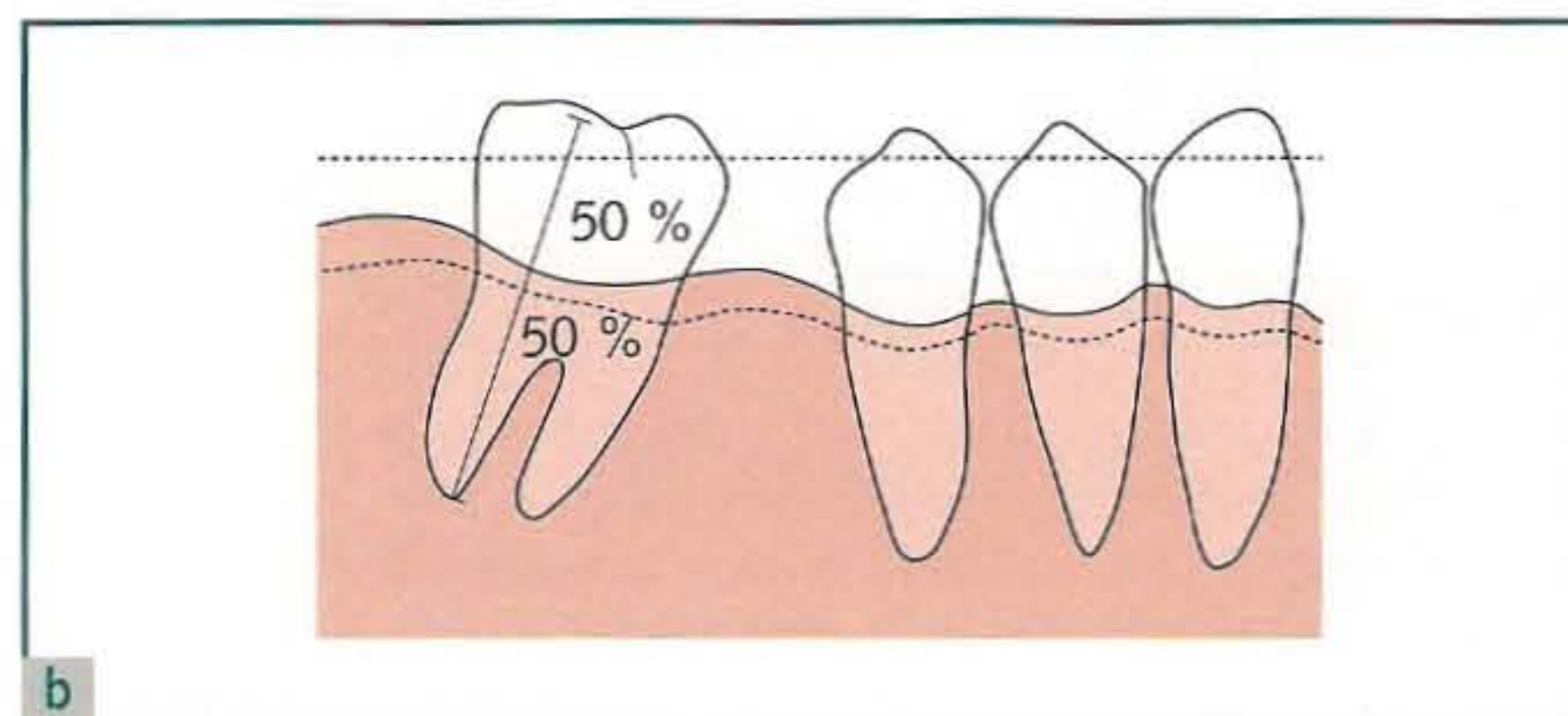
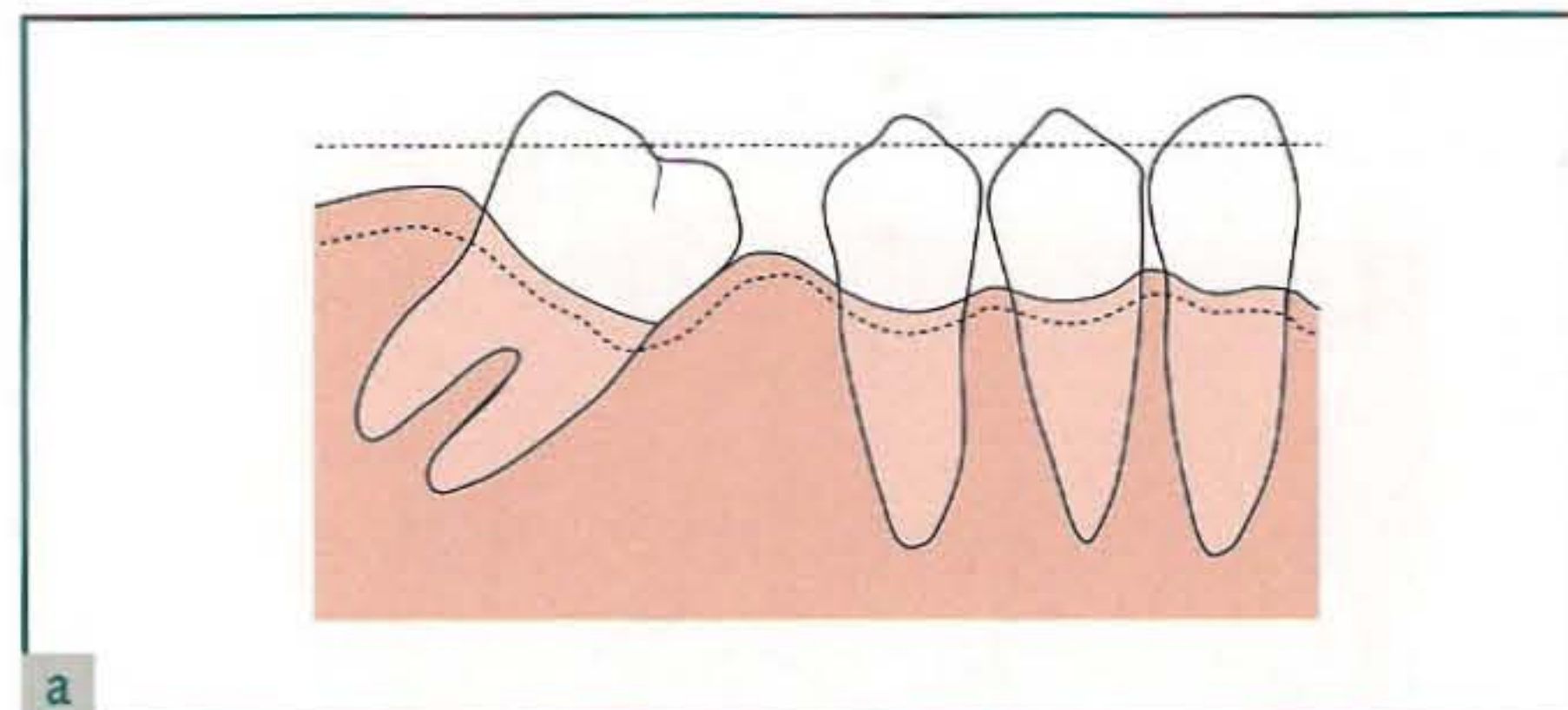


Fig 7-11 (a) The second molar is mesially positioned; (b) the molar is corrected with a combined movement of uprighting and extrusion.

- Movement of the roots in a mesial direction while the crown maintains the same position.
- Movement of the crown in the mesial direction and closure of the space.

The use of a lingual arch serves as an anchor and allows control of the transverse and rotational forces. The use of an inclined plane on the opposing arch is often necessary to avoid occlusal interference, a frequent cause of treatment failure.

In the cases in which the crown must be considerably reduced, it is advisable to plan the endodontic therapy before the orthodontic treatment is started. One of the most efficient techniques is the use of sectional arches with an uprighting spring (Fig 7-10).

Variations in the forces and the point of application also make it possible to control the extrusion.^{19,20} The amount of force must be controlled and calculated in relation to the tissue and periodontal situation. The movements obtained must be slow, constant, and the most physiologic possible (for example, in ideal situations, the correct force for uprighting movement is 2,000 g/mm). The use of the correct force avoids undesirable and damaging secondary effects, which are often the cause of failure (root resorption, worsening of the pseudopocket, and excessive tooth mobility).²⁰

The only situation for which a removable appliance can be used is distalization of the crown, when the consequent extrusion is acceptable or even planned, for example, when correction of the crown-root relationship is desired (Fig 7-11).

Fig 7-12 Uprighting movement is obtained with a fixed appliance with a dual spring, buccal and lingual, that moves the mesially inclined molar in the distal direction.

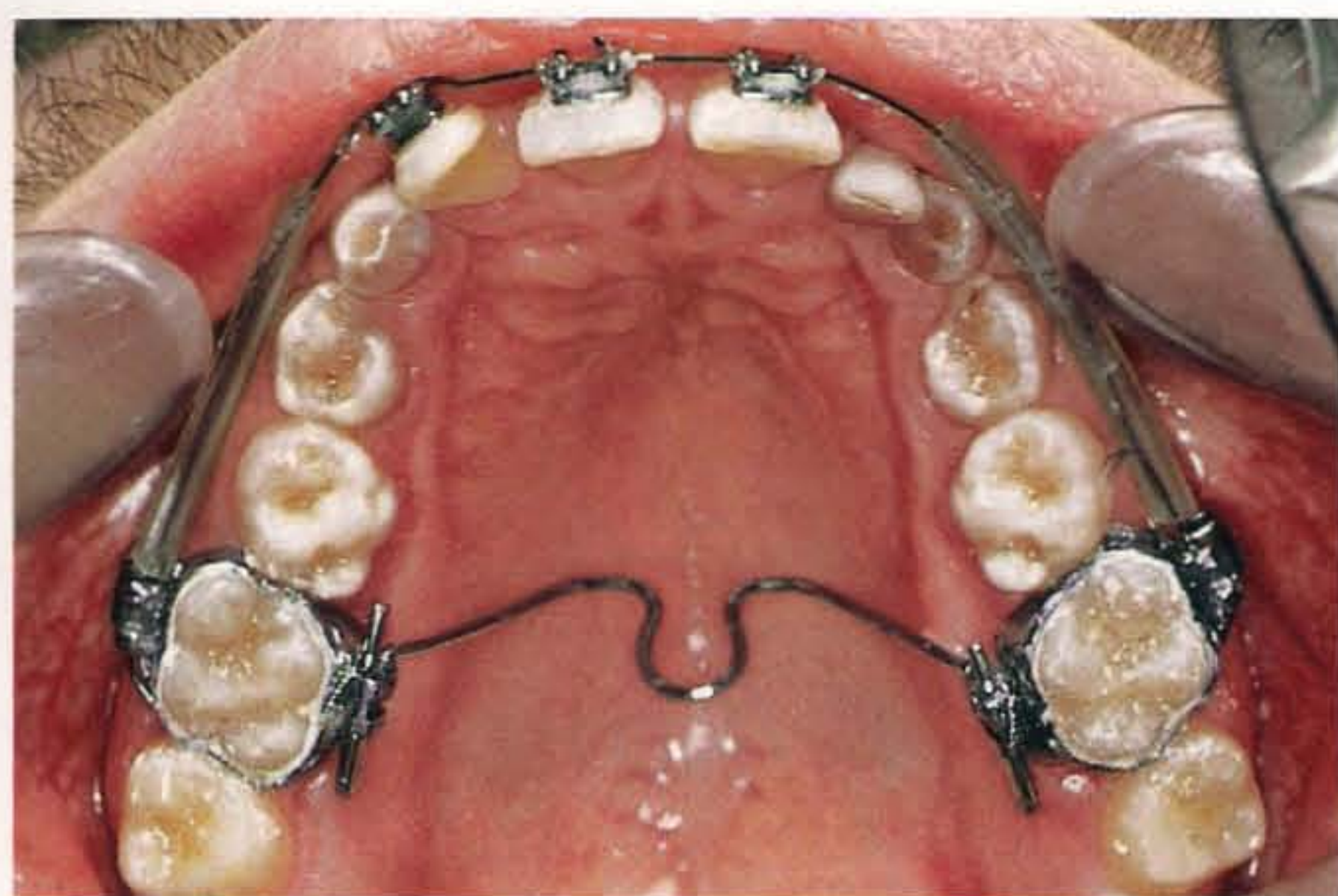


Fig 7-13 Intraoral view of a transpalatal bar.

Distalization of the crown can also be carried out with a fixed appliance using a double section, buccal and lingual, with a spring and an open loop. The spring is applied in contraction and, as it returns to its natural length, tends to move the molar crown distally (Fig 7-12).

The duration of treatment varies between 3 and 8 months, depending on the movement needed.

Retention

Once the desired result has been obtained, the teeth must be kept in retention for 3 to 6 months, in this way assuring adequate stability of the tooth movement. This stabilization can be obtained with the same fixed appliance, no longer active, or with a provisional prosthesis.

Crossbite

A crossbite can involve a single tooth or a group of teeth; correction is necessary when crossbite causes occlusal trauma and functional alterations.¹⁷ A solely prosthetic correction can cre-

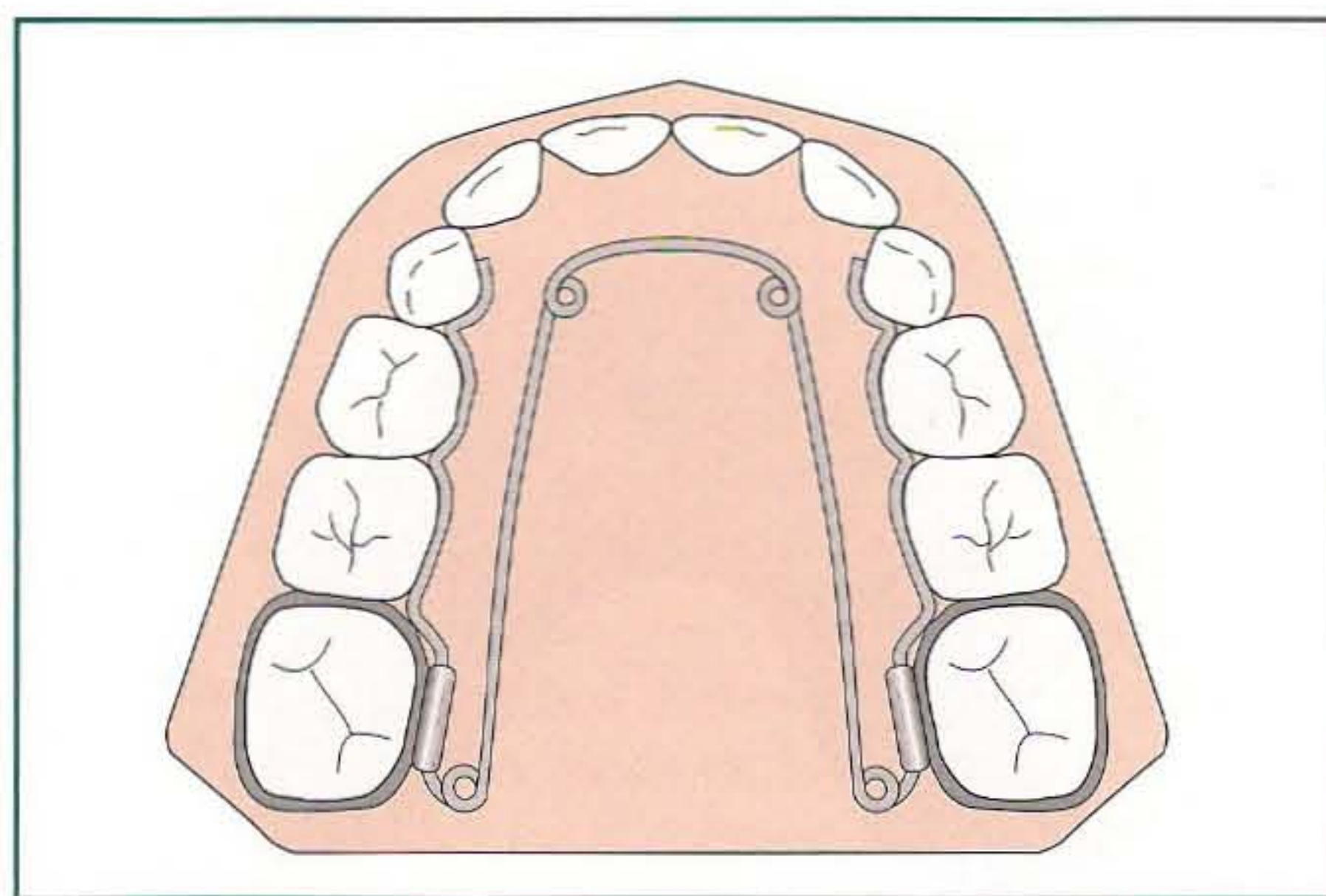
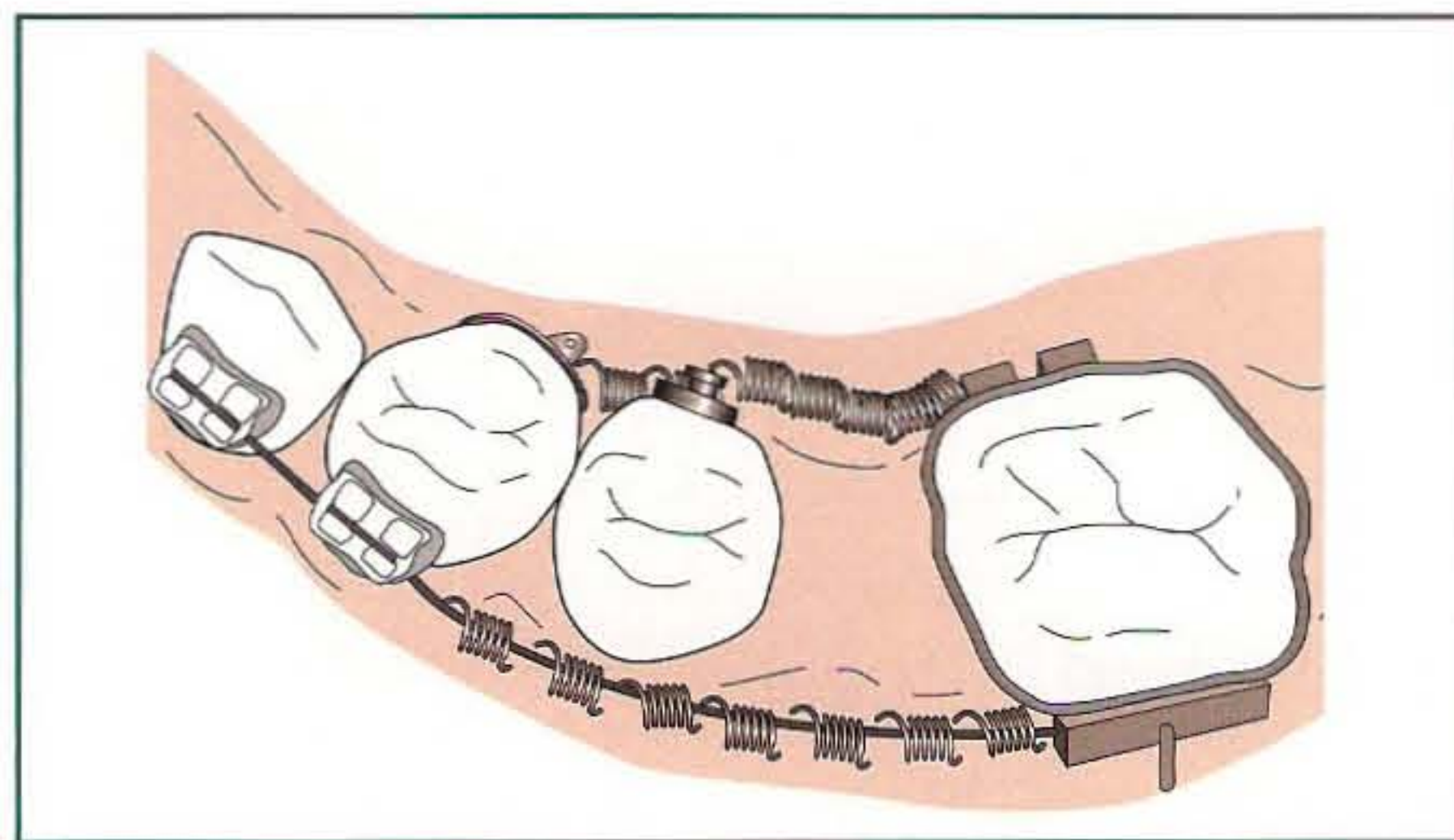


Fig 7-14 Maxillary cast with a quad-helix for the correction of crossbite.

ate a forced mandibular lateral deviation; in these cases, it is necessary to proceed to an orthodontic intervention.

Appliances for correcting crossbite

When the space is sufficient to allow alignment, the treatment is simple, and a removable splint with screws or springs can be used. The use of fixed appliance, such as a transpalatal bar or quad-helix (Figs 7-13 and 7-14), presupposes a certain experience and must be limited to cases in which it is necessary to simultaneously resolve the rotation of one or both molars or a crossbite involving several teeth of the lateroposterior sector.

When space is limited, the appropriate treatment is a fixed appliance that includes all of the teeth of the arch, used in combination with a sulcular inclined plane to eliminate occlusal contacts that would impede realignment of the teeth in crossbite.

The duration of the treatment is between 3 and 8 months, depending on the extent of the problem, the age of the patient, the periodontal condition, and, if a removable appliance is used, the cooperation of the patient.

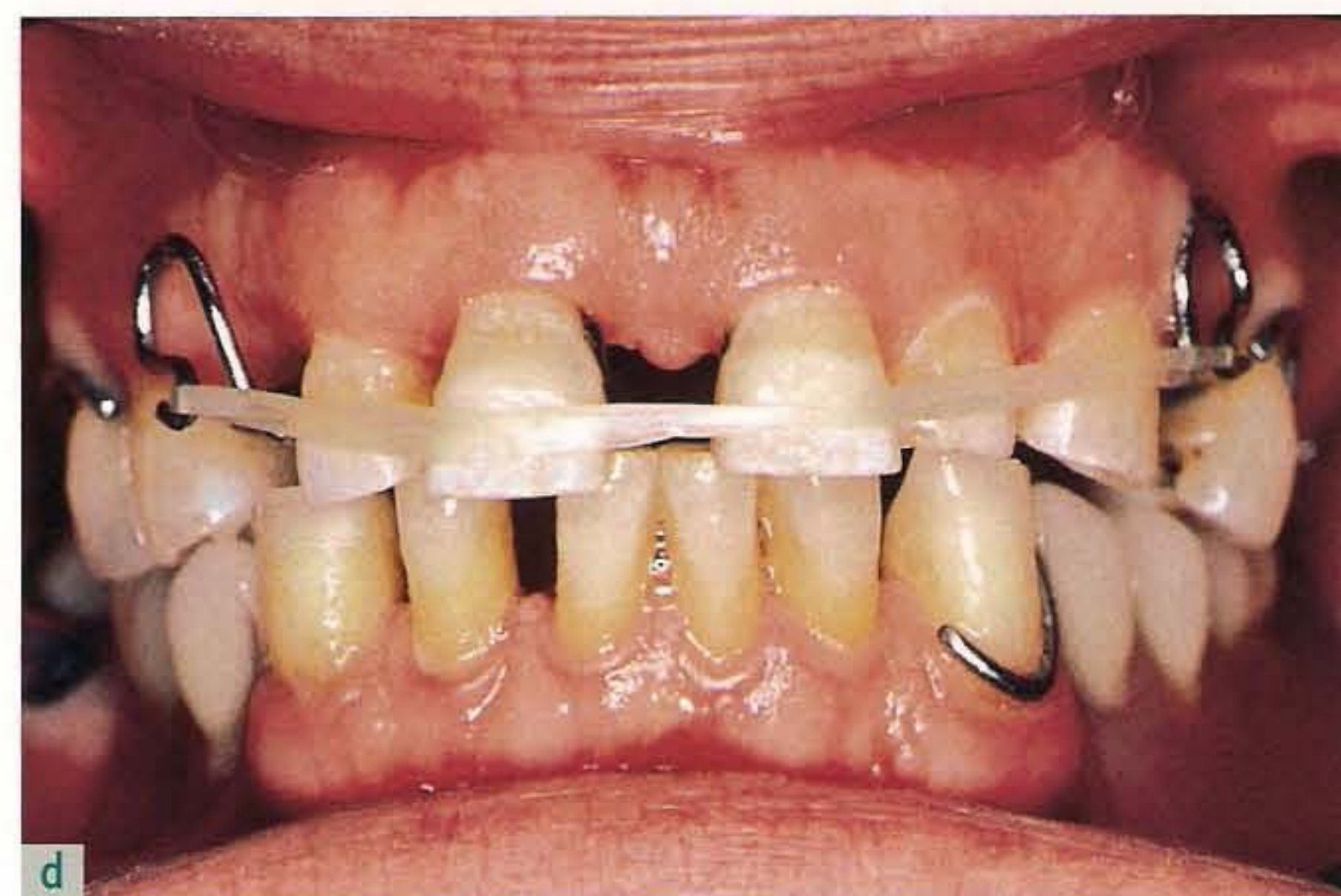
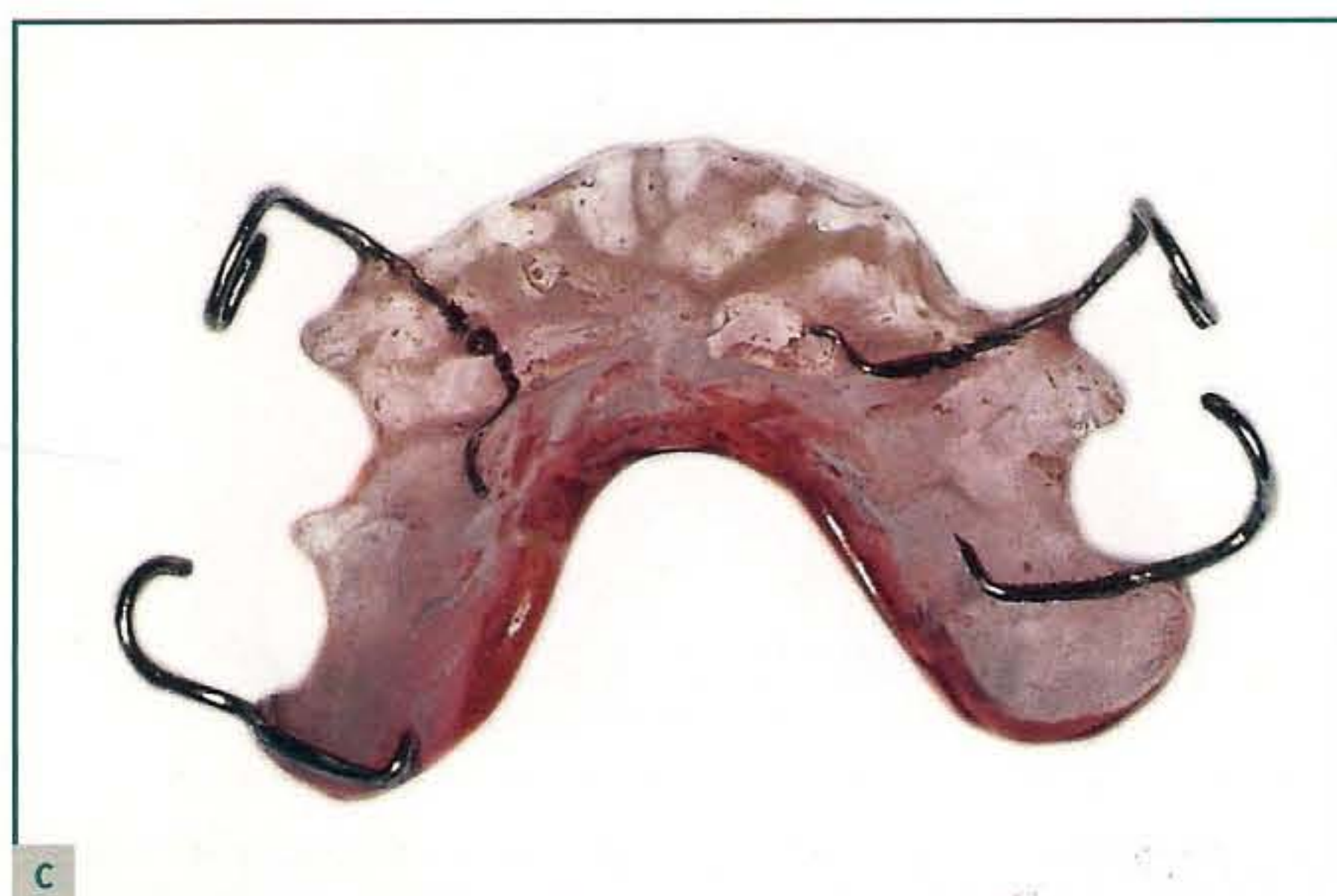
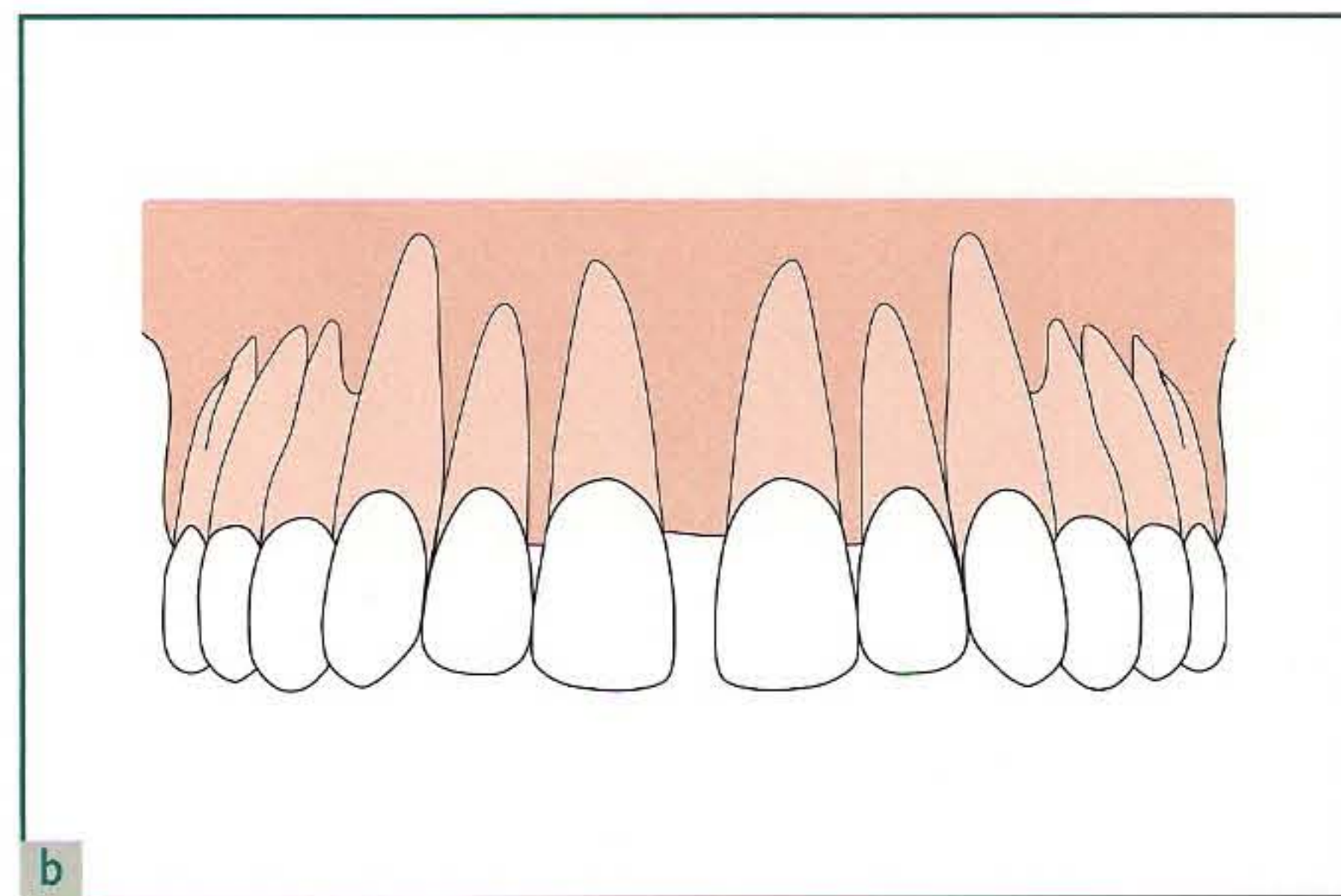
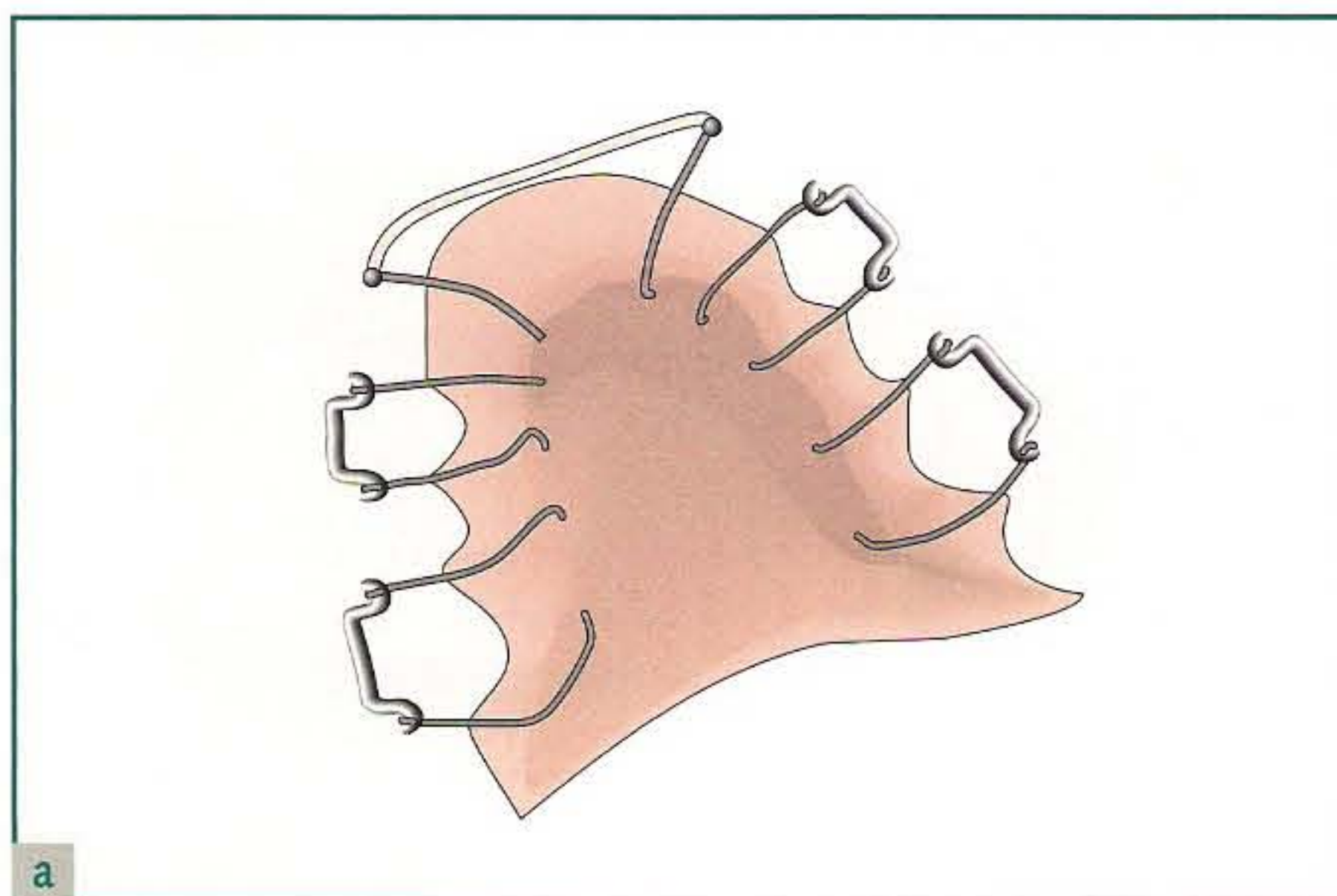


Fig 7-15 (a) Removable maxillary splint with anterior elastic for closure; (b) interincisal diastema; (c) splint without the elastic; (d) intraoral view of the removable splint with an anterior elastic.

Retention

The posttreatment stabilization time is at least 3 months with a provisional prosthesis that allows adaptation to and maintenance of the new occlusal position.

Alignment

Alignment has the goal of modifying incorrect positions of one or more teeth or moving them into a more favorable position for prosthetic intervention.^{2,12,17}

In the case of a shortened arch or in the presence of a space, distal movement of adjoining teeth or mesial movement of one tooth can be useful to create fixed partial denture abutments or the space needed for insertion of an implant.

Crowding or diastemas are situations that most frequently need orthodontic alignment.²¹

A diagnostic setup is essential when treatment is planned, in order to establish the movements to be carried out, the coronal reshaping and modeling, the prosthetic elements to be pre-

pared, and the teeth to be extracted. However, the ideal movements predicted with the setup cannot always be realized with orthodontics.

Appliances for alignment

Closure of diastemas is considered a relatively simple process when it can be obtained with removable plates that have hooks for anterior rubber bands or screw closure (Fig 7-15).

If it is necessary to rebalance the spaces present in the arch, redistributing them in a way that will allow a prosthesis, it is beneficial to use fixed appliances with which the operator knows how to measure the extent of the forces. These forces must always be light (10 to 20 g per tooth) and combined with frequent and thorough intervention by a periodontist. Clinicians must evaluate the tissue reaction of the patients and decide whether to keep to the chosen therapeutic plan or vary it, because the degree of forces used to obtain the same tooth movements can differ from patient to patient.

An example of a change in prognosis tied to dental orthodontic movement would be the case of a shortened arch where the posterior teeth are missing and the second premolar is then moved distally to be used as a fixed partial denture abutment. The fixed appliance can be used to create space for an implant between the roots of two teeth that are either too close or are convergent.

The duration of treatment is variable in relation to the patient's age, the health of the tissues, the extent of movement needed, and oral hygiene, but in general treatment does not last for more than 6 to 8 months.

Retention

A fixed provisional prosthesis or a resin-bonded fixed partial denture can be used for stabilization.

The indications for preprosthetic orthodontic therapy have been subdivided and classified into various problems to make the explanations easier. In daily practice, however, clinicians are confronted with various combinations of problems; it is therefore fundamental to accurately evaluate every case in its entire complexity and plan the solution with great clarity. The clinician should remember that the simplest solutions, often relegated to a less important status, are frequently the most advantageous strategy and are very satisfying for the patient.

Implants in Orthodontic Treatment

Orthodontics is also used to redistribute the edentulous spaces with the aim of allowing the placement of implants necessary to complete a prosthetic treatment that would otherwise be impossible.

Stable and controlled anchorage is the basis of success in orthodontic therapy. Implants, therefore, can act as an ideal anchorage because of their stability in the bone. This concept is not new and has been the subject of numerous publications over the last 50 years.²²

The many materials used in various implant systems can be grouped into three categories²³:

1. Biocompatible (steel; chrome-cobalt alloys)
2. Bioinert (titanium-carbon)
3. Bioactive (hydroxyapatite; glass ceramics)

The material that is most commonly used is titanium, which is light and has considerable resistance to traction, the stress of orthodontic forces, and the masticatory load.

Implants that have the sole function of orthodontic anchorage are available, as are implants that are used both for prosthetic and orthodontic purposes. If the implant has a double role, that is, as an orthodontic anchor and as a prosthetic ele-

ment, the area of insertion must satisfy two types of forces, and it is therefore advisable to carry out a diagnostic setup to define the correct placement of the implants.²³ If the implant is only orthodontic, the location of insertion can be optimized according to the needs of the orthodontic mechanics. It is also possible to use very small implants. At the end of the treatment, the implants can be left in the site ("sleeping implant").

Studies have shown that titanium implants with screws of 2 mm in diameter and 9 mm in height can be placed under load after 4 weeks, without waiting for complete healing of the bone, because the stability of the implant in the bone is sufficient for orthodontic anchorage.^{24,25} Early application of force seems to create fibrous tissue, interposed between the bone and the implant, that does not compromise the stability of the implant subjected to orthodontic load. According to some authors,²⁵ this condition is even considered favorable because it can facilitate the surgical removal of the implant at the end of the treatment. The anatomic sites most frequently used are the alveolar bone, in cases of agenesis or extraction, the palate in the medial or paramedial zone, and the retroincisal or retromolar areas. Clinical and laboratory studies have shown that anchorage always remains stable, both when subjected to forces of a low and medium degree (30 to 250 g), as is common in orthodontics, and when exposed to greater forces (400 to 1,500 g), as is common in orthopedics.²³

The orthodontic implant inserted in the palate, both in the medial and paramedial zones, is of the osseointegration type and requires a waiting period of about 3 months for the osseointegration before it can be subjected to loads. It is used as anchorage as a substitute for extraoral traction. Once the treatment is finished, the implant can be removed or left in situ.

Other types of orthodontic implants are:

- Mini implants (8-, 10-, or 12-mm lengths; 1.5- to 2.0-mm diameters), which are applied from the buccal side of the arch with either a standard procedure or a transmucosal procedure. After about 2 weeks, it is possible to connect the implants to the orthodontic appliance with small chains, elastics, or springs. These implants (surgical stainless steel) are not osseointegrative; for this reason, at the end of treatment, they must be removed.
- Screws for orthodontic anchorage for immediate loading. These are nonosseointegrative implants. These screws have rectangular and vertical grooves that allow for the insertion of the orthodontic wires. The implants have a diameter of 2 mm and a length of 7, 9, or 11 mm. They can be used as anchors to obtain intrusion in the posterior segments or anteroposterior movements.



Fig 7-16 (a and b) This 52-year-old patient has esthetic and periodontal problems.



Fig 7-17 (a and b) The maxillary left central incisor is rotated and extruded.

Case report

A 52-year-old woman presented for treatment because she had esthetic and functional problems in the maxillary incisor area. The patient's smile was seriously compromised by the anomalous position of the maxillary left central incisor, which was so extruded, rotated, and protruding that her lips could not close. A clinical examination revealed an increase of overjet. An intraoral inspection revealed that the maxillary right second premolar, mandibular left central incisor and first molar, and mandibular right first and second molars were missing (Figs 7-16 to 7-19). The maxillary left central incisor was considerably periodontally compromised, but, in view of the patient's high level of cooperation and her desire to save her tooth "at any cost," the therapeutic plan was designed to allow conservation of the tooth in question and its maintenance in place by a permanent fixed retainer. A prosthetic rehabilitation with a resin-bonded fixed partial den-

ture was planned in both the maxilla and mandible to replace the missing teeth, and individual metal-ceramic crowns were to be made for the mandibular left first and second molars (36 and 37). To reposition the maxillary left central incisor and improve the alignment and the overjet, a fixed orthodontic appliance designed according to the straight-wire technique^{21,26} was combined with a transpalatal bar as molar anchorage (Fig 7-20). Very light orthodontic forces were used to obtain tooth movement that would improve the periodontal condition. The treatment lasted about 10 months. The patient was constantly encouraged to maintain a good level of oral hygiene, and, over the whole period of orthodontic treatment, root planing was performed regularly. The patient's cooperation played an important role in the final success of the therapy and permitted realization of the planned treatment. At the end of prosthetic rehabilitation, the smile was further improved and the imperfections were corrected with enameloplasty (Figs 7-21 and 7-22).

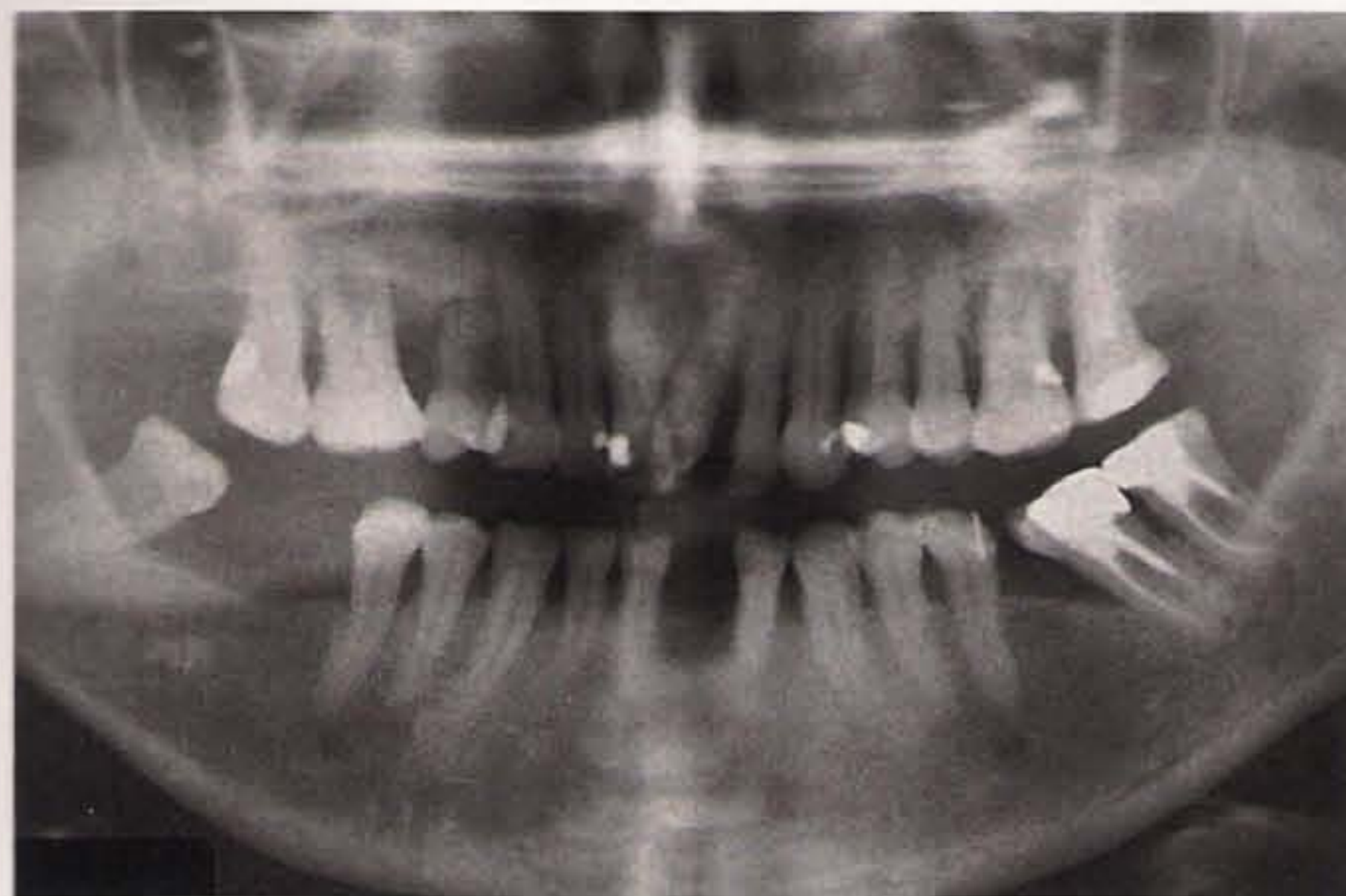


Fig 7-18 The panoramic radiograph reveals serious bone loss in both arches.

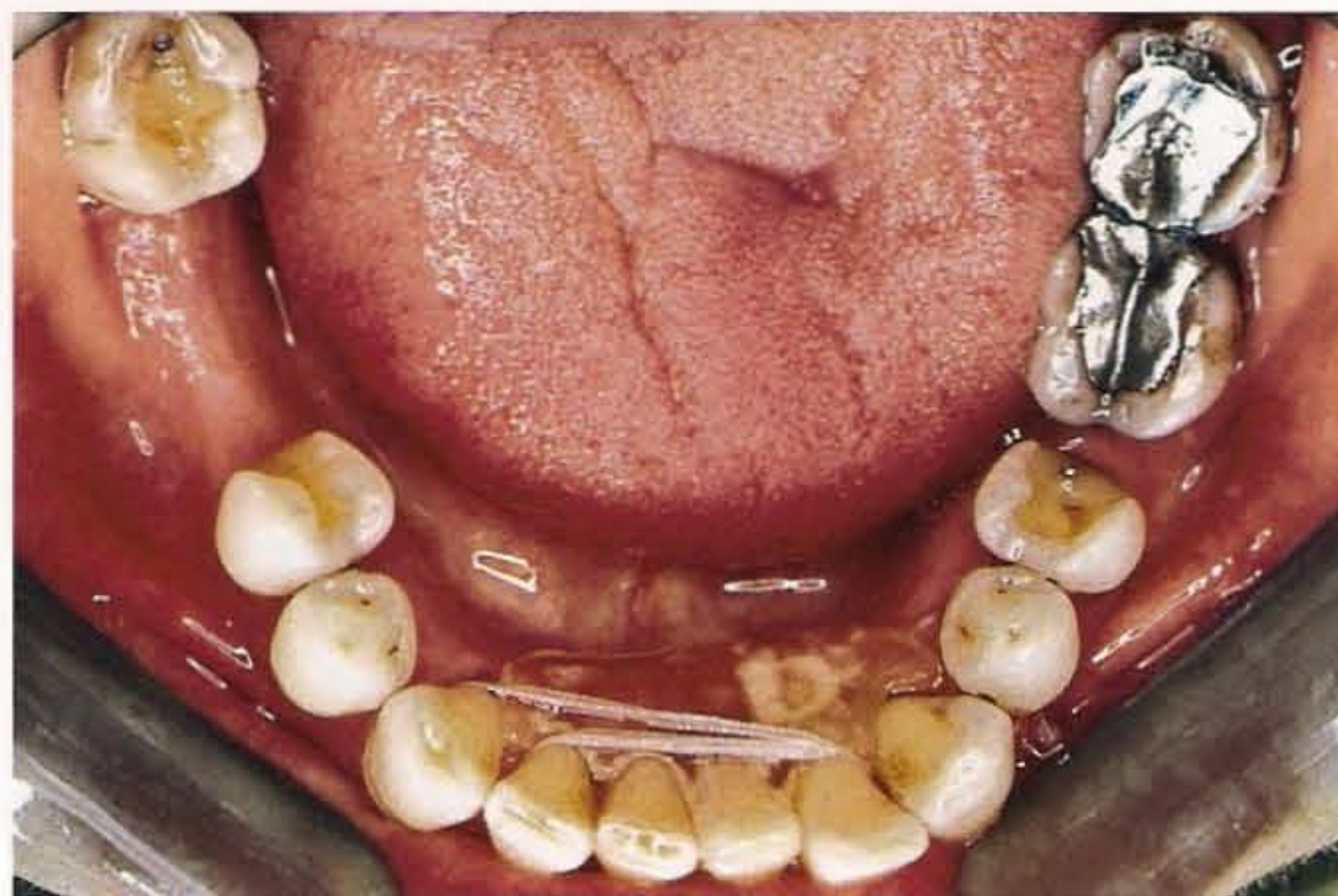


Fig 7-19 The mandibular arch is corrected with a removable prosthesis adapted to the patient.



Fig 7-20 The position of the maxillary left lateral incisor is corrected with a fixed appliance with the straight-wire technique.



Fig 7-21 The final result is retained with a resin-bonded fixed partial denture.



Fig 7-22 The patient's smile is shown at the end of the treatment, (a) before and (b) after enameloplasty.

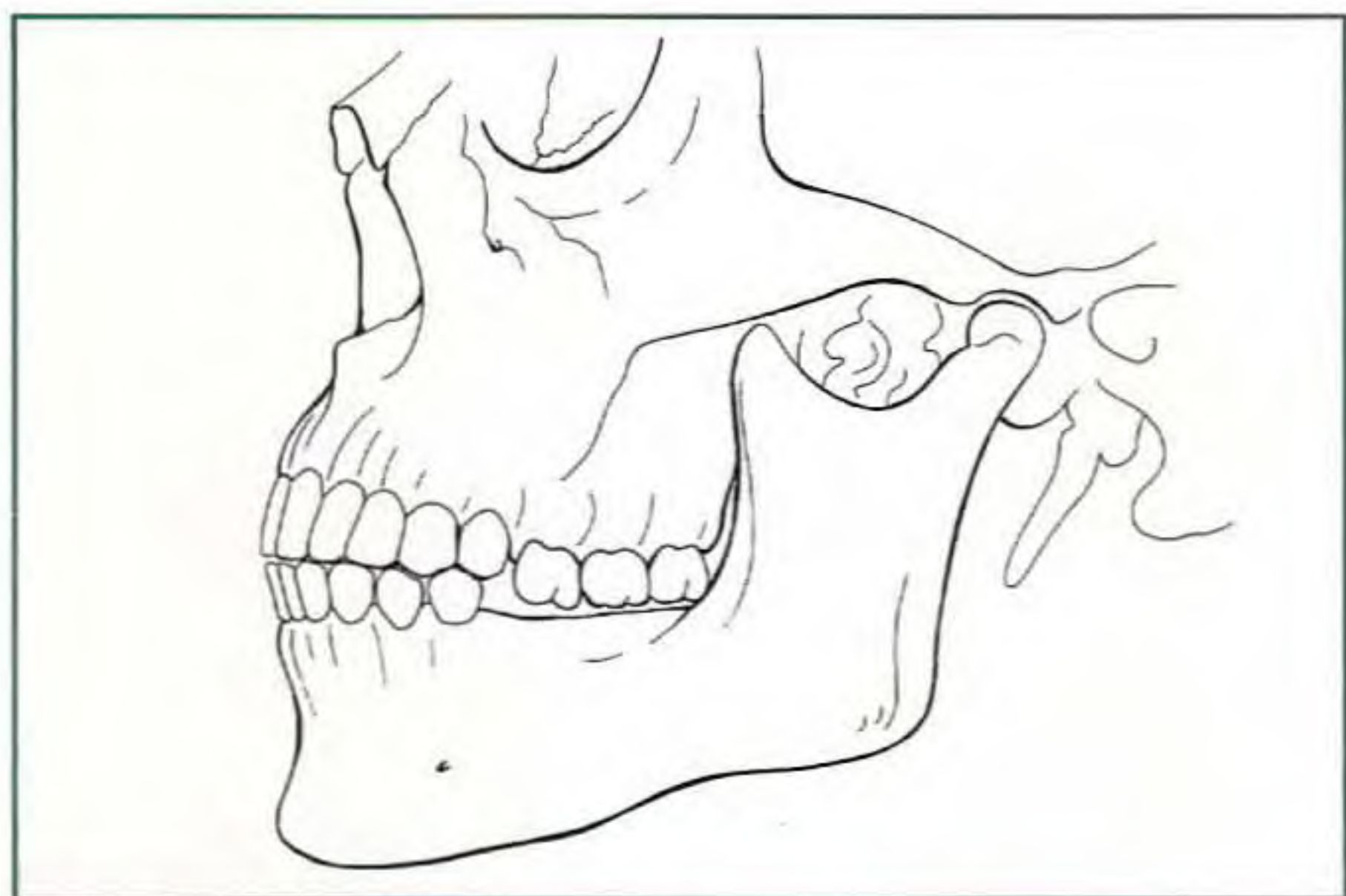


Fig 7-23 Collapse and extrusion of the maxillary dentoalveolar segment with an opposing mandibular edentulous segment.

Preprosthetic Segmental Osteotomy

Indications

Segmental osteotomy of the maxilla is an indispensable support for prosthetic treatment of certain anatomic irregularities in the posterior quadrants of the dental arches.^{27,28} The monolateral or bilateral loss of mandibular molars can result in the extrusion and collapse of the opposing dentoalveolar segment (Fig 7-23). In these situations, the vertical space needed for restoration with a removable or an implant-supported prosthesis is greatly reduced or even eliminated. An objective examination reveals a protrusion or extrusion of the opposing maxillary dentoalveolar segment into the edentulous zone. This segment may, in extreme cases, be in direct contact with the edentulous mandibular alveolar crest.

When both the maxillary and mandibular posterior segments are edentulous, a phenomenon similar to extrusion of the edentulous maxillary segment that reduces the space between the arches is found. This morphologic alteration arises because of the absence of prosthetic rehabilitation of the lateral occlusal sectors, assisted by the progressive approach of the dentoalveolar process to the osseofibrous tissue component. This occurrence does not appear to be caused by new osseous apposition but rather by a process of tissue migration associated with passive eruption of the teeth in the absence of opposing teeth.²⁹ In the maxilla in particular, such migration brings about a morphologic modification of the maxillary sinus, which expands downward.

Surgery aimed at reestablishing a sufficient space between the arches and a correct occlusal plane can include:

- Endodontic treatment of the extruded teeth followed by a reduction in height of their clinical crowns and a periodontal lengthening of the teeth.
- Orthodontic intrusion treatment of the extruded teeth.
- Surgical intrusion of the collapsed segment^{30,31} when the loss of space is almost total (Figs 7-24 and 7-25).

The technique for segmental osteotomy of the maxilla was initially carried out in two stages; it was later modified to a one-stage procedure.^{32,33} The surgery allows the upward repositioning of a dentoalveolar segment of the maxilla, maintaining the vitality of the teeth involved, and in this way gains the space necessary to prosthetically restore the occlusal sector in question.³⁴

Beside the specific methods proposed, the techniques that are successful in a biologic and clinical sense are based on the following surgical principles:

- Maintaining a sufficient quantity of attached and vital soft tissue on the mobilized segments, with the aim of providing sufficient vascularization.
- Allowing maximum visibility of the osseous sectors that must be osteotomized.
- Obtaining good mobilization of the segments to allow their passive repositioning in the planned sites.
- Keeping periodontal tissues in the best possible condition.
- Supplying the most extensive and stable contact possible between the osseous segments, with the aim of encouraging rapid healing.³⁵

Diagnostic evaluation and therapeutic guide

The diagnostic criteria, as mentioned earlier, refer to the evaluation of the space in the posterior edentulous zone. Surgical treatment is advised when the maxillary dentoalveolar segment is extruded to the point where it brushes against or has direct contact with the edentulous crest.^{36,37}

Diagnostic judgment is primarily based on direct clinical evaluation, but must be supported both by an examination of the plaster casts of the arches and by radiographic examination, such as panoramic and cephalometric radiographs (Figs 7-26 and 7-27). These examinations allow the clinician to establish the extent of the lacking vertical space with certainty, quantifying it with precision and therefore making it possible to select the type of intervention when the lack of space is moderate. As discussed earlier, the treatment performed by the prosthodontist consists of devitalizing the teeth in question, shortening their clinical crowns, and successive periodontal lengthening of the teeth. When the loss of space is serious, the prosthodontist

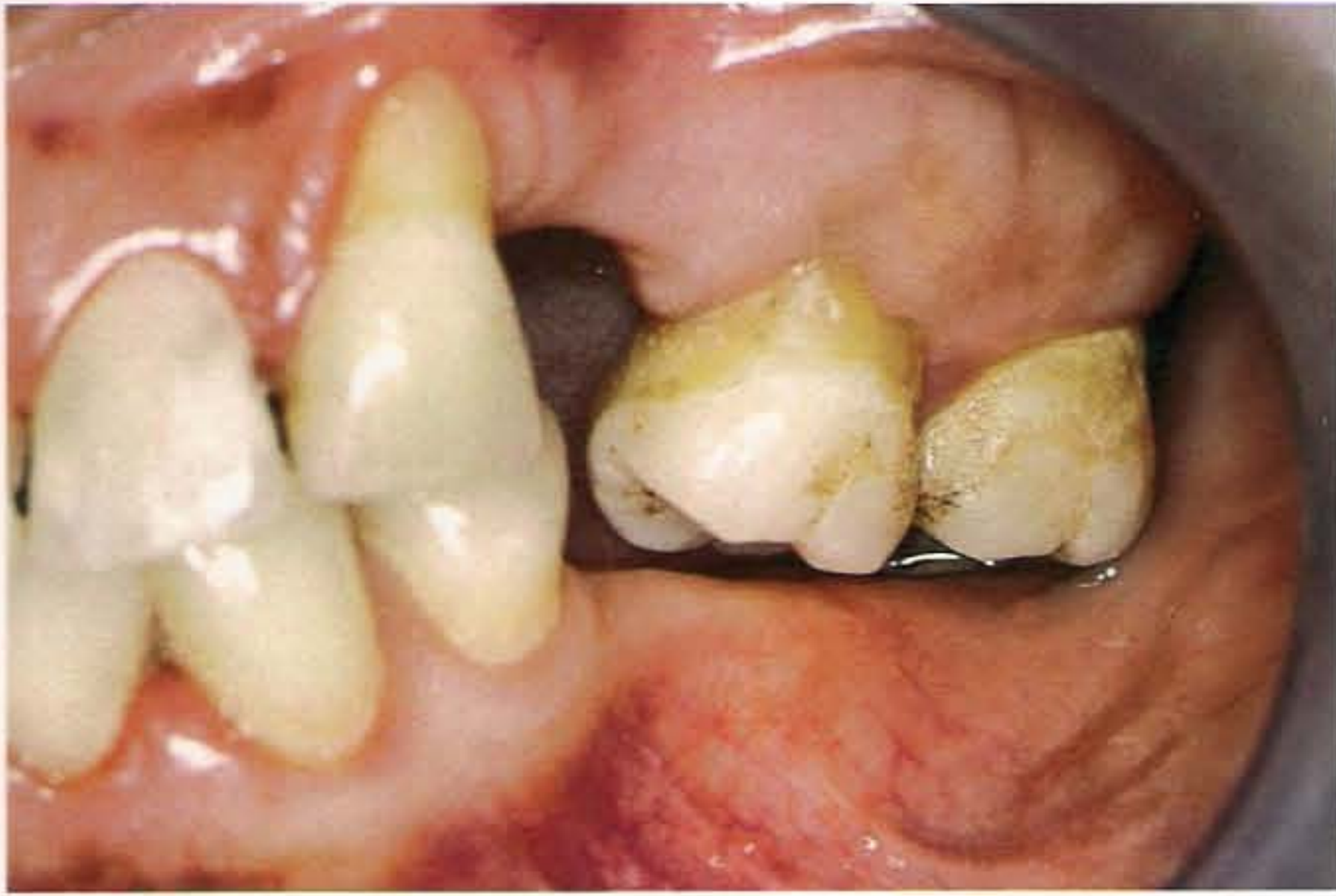


Fig 7-24 Dentoalveolar collapse of the maxillary left first and second molars, where the two teeth touch the opposing edentulous alveolar crest.

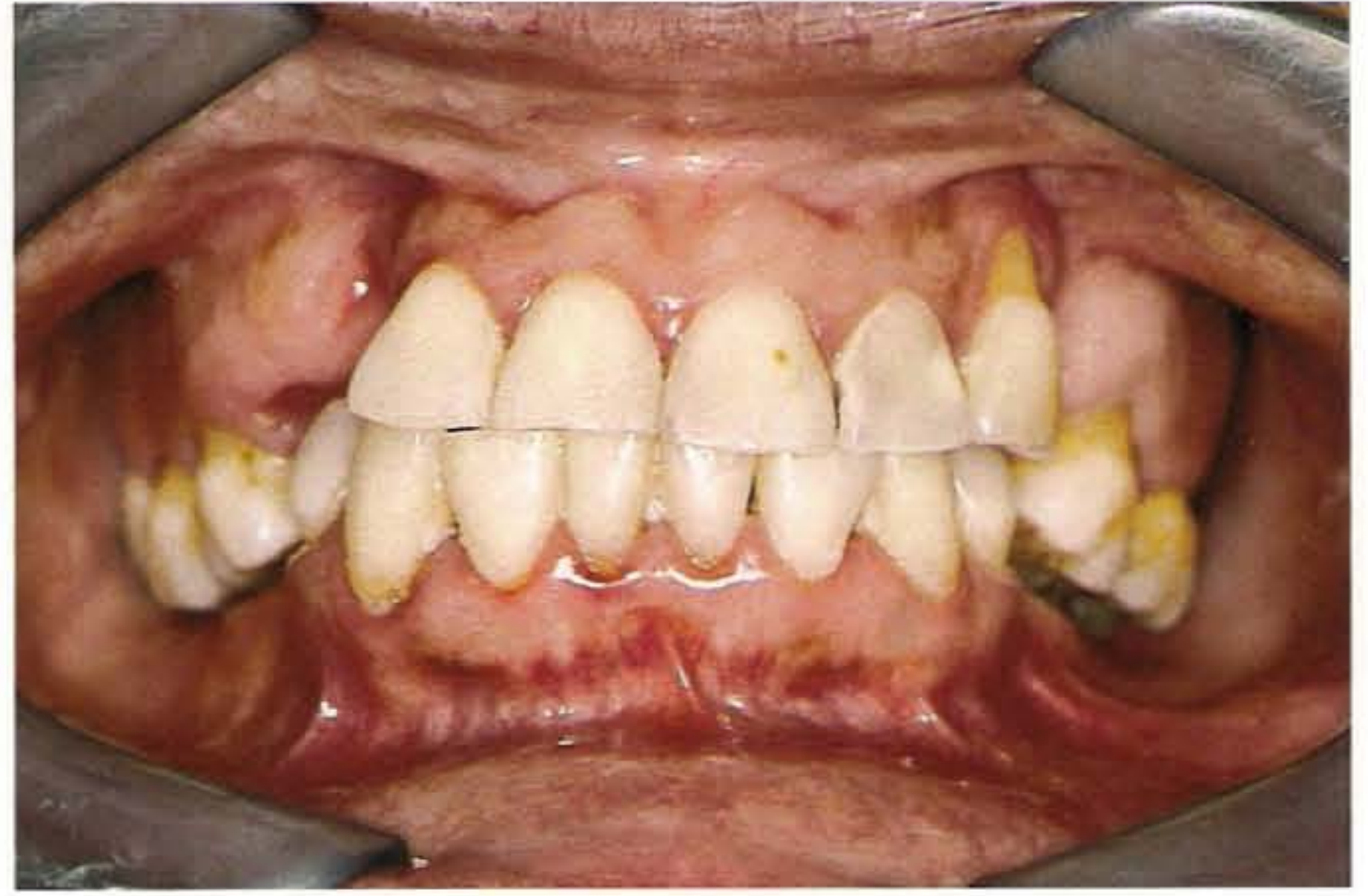


Fig 7-25 Dentoalveolar protrusion may also be bilateral when both sides have edentulous opposing arch segments.



Fig 7-26 Radiographic evaluation with a panoramic radiograph of a patient who exhibits bilateral dentoalveolar collapse. The morphologic changes also involve the maxillary sinus, in which the inferior membrane accompanies the extrusion of the dentoalveolar segment.



Fig 7-27 Lateral cephalogram of the same patient shown in Fig 7-26. The maxillary second molar touches the mandibular edentulous alveolar margin.

must involve an orthodontist or maxillofacial surgeon in the treatment plan.

When the lack of space is such that it does not allow for a conservative solution or when a surgical procedure is chosen, it is necessary to continue with preoperative investigations. The evaluation of the state of the maxillary sinus is very important. This evaluation can be carried out through endoscopy or through a radiographic examination to exclude the presence of acute or chronic sinusitis. Although the opening of the healthy maxillary sinus is harmless, the same cannot be said for a sinus cavity with an established inflammatory process.

The surgery must be performed while the patient is under general anesthesia and requires a 2- or 3-day period of recov-

ery. After this time, the patient can gradually resume normal activity. Significant edema of the cheek that subsides in a few days is relatively common; significant postoperative pain is not usually present. Eating via the mouth can be resumed immediately, although the patient should consume a soft diet for several days. A stabilizing appliance fixed to the maxillary teeth is removed 30 days after the surgery (Fig 7-28). In the great majority of cases, the planned result is obtained (Figs 7-29 and 7-30). Failures or complications with significant disturbances for the patient are rare. When there is a complication, it is usually serious.

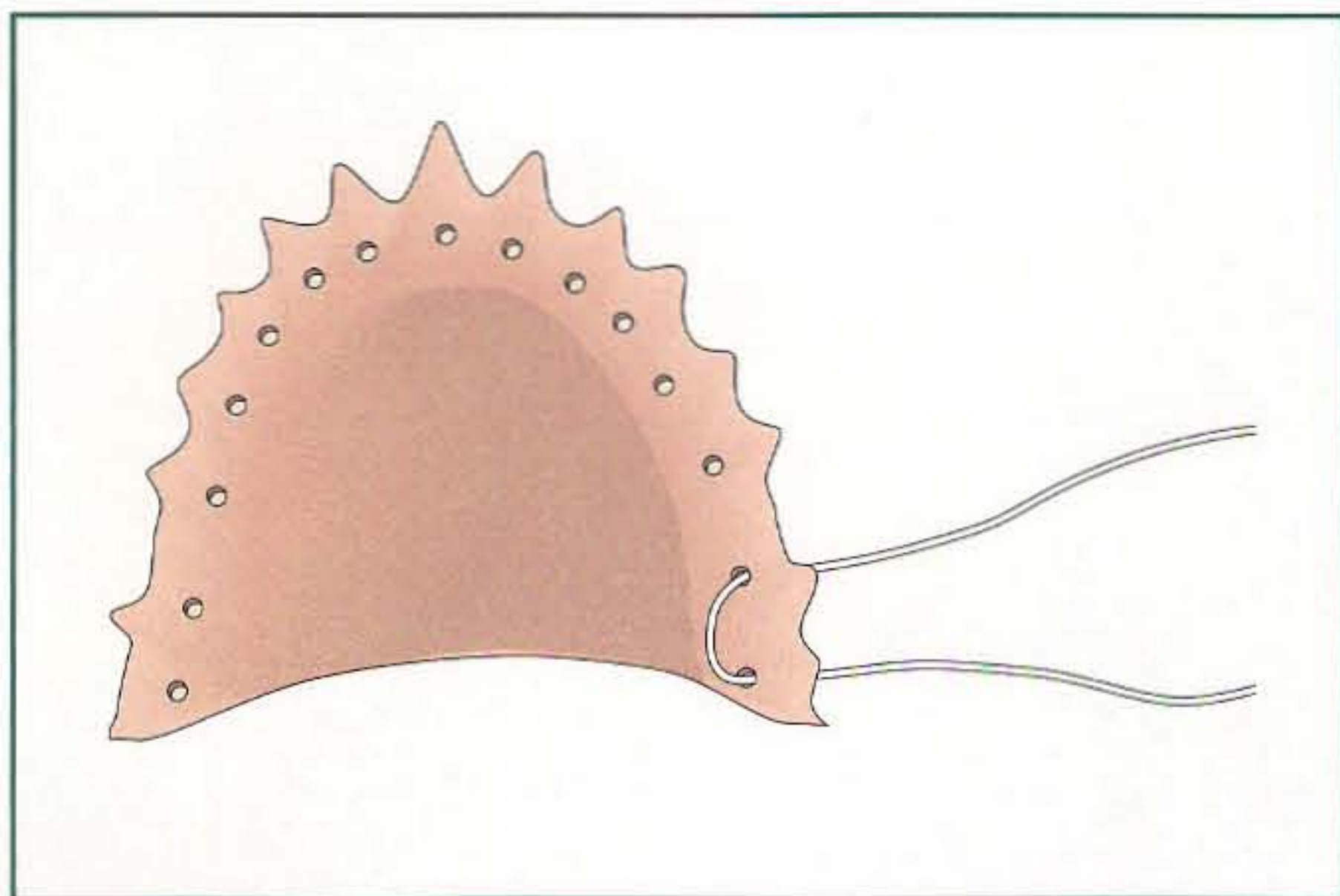


Fig 7-28 A resin retaining splint is fixed to the dental arch by means of metal threads at the end of active treatment and removed after 30 days. Its use during surgery allows exact reproduction of the planned movements.



Fig 7-29 The maxillary left first and second molars exhibit severe collapse, in which the occlusal surfaces are in direct contact with the mucosa of the opposing edentulous crest.



Fig 7-30 The same dentition shown in Fig 7-29 is shown after intrusion of the dental-osseous segment to recover vertical space, which has permitted prosthetic restoration of the mandibular arch.

Surgical planning

Planning the surgery calls for strict collaboration between the surgeon and the prosthodontist. The prosthodontist must precisely clarify the degree of displacement necessary to enable placement of an optimal prosthesis, and the surgeon must evaluate whether he or she can obtain the desired result.³⁸

The surgery must be simulated on plaster casts of the arches mounted in an articulator. The segment in question is cut and repositioned according to the treatment plan and then fixed in position with wax adhesive. This procedure serves to measure the prosthetic space that will be obtained and to prepare the stabilizing appliance that will be placed during the intervention, to demonstrate the exact degree of planned displacement and the eventual position of the maxillary osteotomized segment (Figs 7-31 and 7-32).

Surgical procedures

Maxillary segmental osteotomy has, over time, been accomplished through various approaches. Every new effective proposal has been aimed at making the procedure more rational. The prosthodontist who is familiar with the basics of surgical technique is better able to advise the patient as to whether the surgery should proceed or not.

Buccal osteotomy

An incision in the buccal mucosa is made, following a horizontal line from the canine to the second molar, and an almost exclusively apical flap is detached; the caudal flap is cut only in the area where vertical anterior osteotomy has been planned. Posteriorly, the periosteum is freed from the tuberosity of the maxillary sinus to the infratemporal fossa.

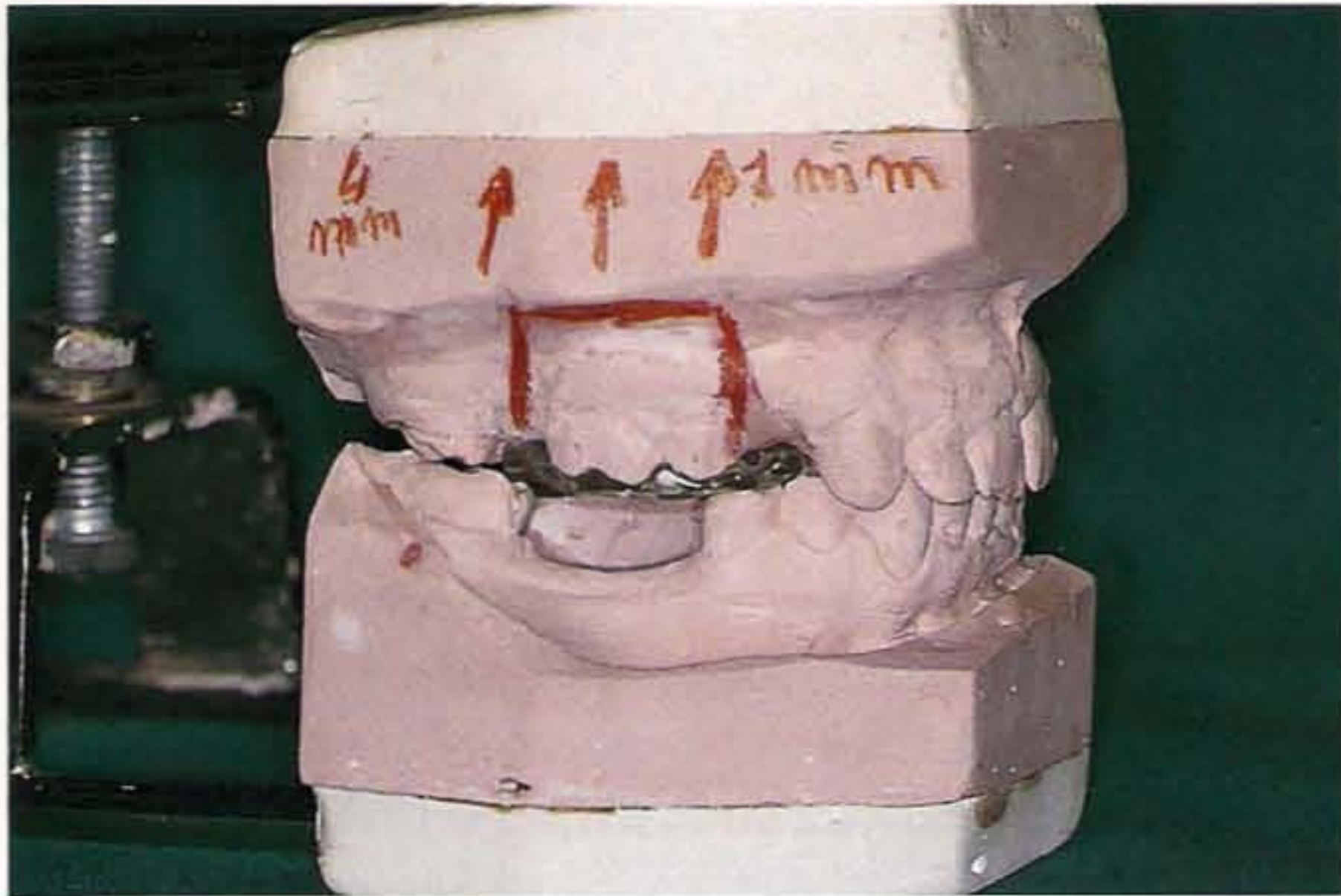


Fig 7-31 Treatment planning on a plaster cast (right side) and preparation of the occlusal splint.

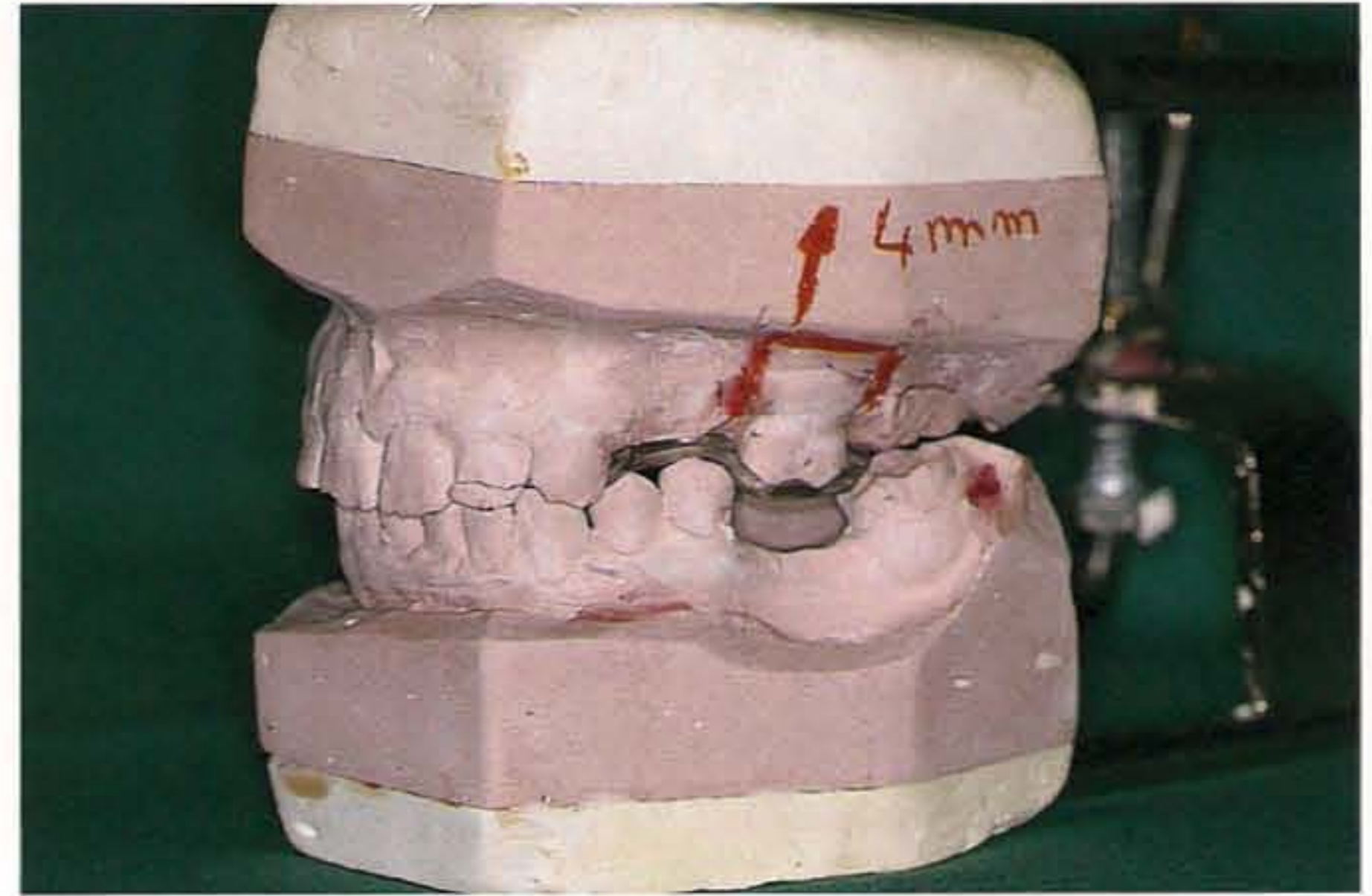


Fig 7-32 The same cast shown in Fig 7-31 (left side). The cast is marked with the dimension of the planned impact.

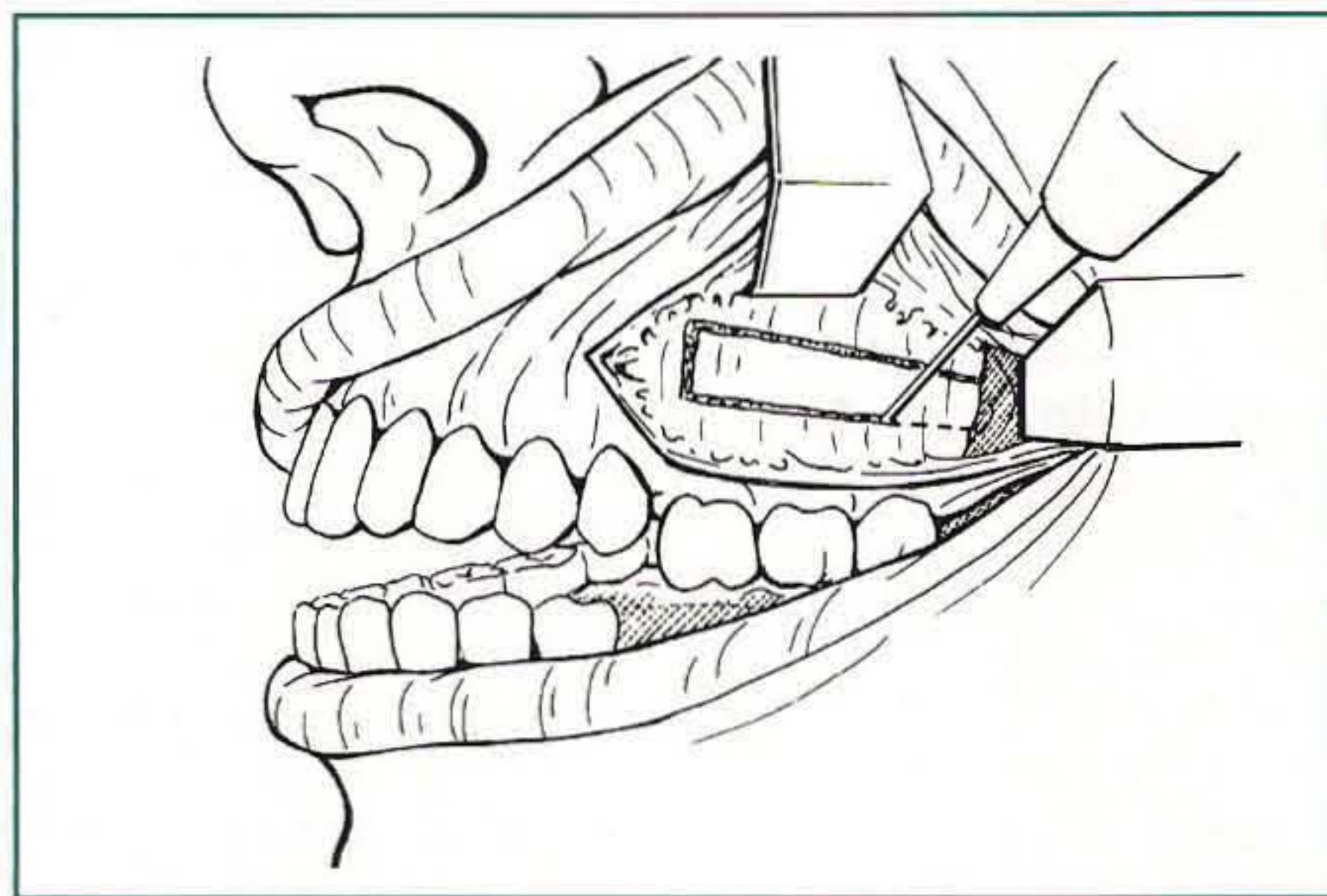


Fig 7-33 Horizontal buccal osteotomy to remove a strip of cortical bone equal to the dimension of the planned intrusion.

Vertical anterior osteotomy of the intra-alveolar area is carried out carefully, to avoid damaging the tooth roots. A very fine round carbide bur and a thin scalpel are used, and the alveolar process is fractured vertically up to the palatine cortical process.

The horizontal osteotomy, perpendicular to the first osteotomy, is carried to the pterygomaxillary fissure. This is undertaken at a correct distance from the root tips (about 3 mm) and allows the removal of an osseous cortical band that is as high as the degree of planned intrusion. The process ends with vertical posterior osteotomy that is performed with a long thin bur that is introduced in the most perpendicular way possible to the surface of the tuberosity or with a curved scalpel (Fig 7-33).

Palatal osteotomy

Palatal osteotomy must be performed 3 to 6 weeks after the first surgery, because the previous fracture lines tend to ossify. Depending on the original technique, a paramarginal palatal

incision extending from the right second molar to the left second molar is made, including a posterior opening of the fibrous mucosa to expose the palatine arteries on both sides. Then the palatal osteotomy is made sagittally to create a vertical connection with the previous buccal osteotomy line.

The bur or the scalpel is not directed perpendicularly to the palate but obliquely in the direction of the maxillary sinus. If the osteotomy is complete in all areas, finger pressure is enough to mobilize the fragment.³⁹ In 1961, Kapovits and Pfeiffer³⁹ proposed some modifications to this technique, suggesting that the posterior incision should be made in the area of the third molars.

A further variation was introduced by Naumann³² in 1974, calling for buccal access through two vertical incisions and a drainage tunnel in the remaining mucosa. This method, which guarantees a more secure vascularization of the osteotomized fragment, now allowed a single-stage surgical approach.

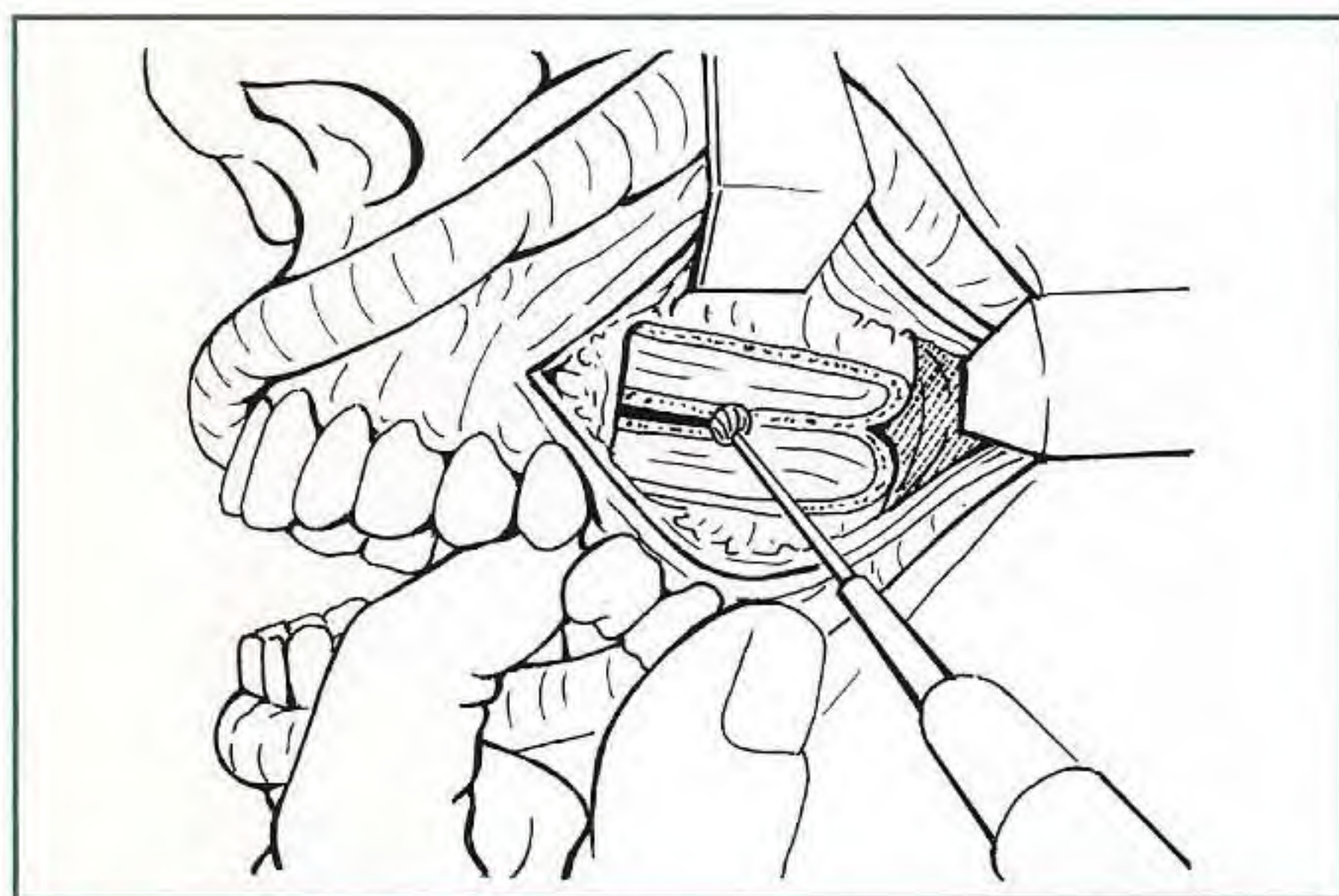


Fig 7-34 Palatal osteotomy via a buccal transantral approach, in accordance with Kufner's technique.

Palatal access that was subsequently adopted allows a more conservative incision and is carried out with a longitudinal paramedial incision; the fibrous mucosa is stripped only partially to reveal the palatine artery and thereby permits sagittal osteotomy and vertical connecting osteotomies.

Another technique allows a buccal transantral palatal osteotomy, thus sparing a palatal incision. In this case, the buccal osteotomy must be rather extended, 5 to 6 mm, to allow longitudinal fracture of the palate with a curved scalpel. This last method, proposed by Epker and Wolford³⁵ in 1980, is certainly more secure, reducing the risks of a reduced vascularization of the bone. It has some limits, however, in terms of its application and is difficult to employ when the palatal vault is not high (Fig 7-34).

When all the osteotomies have been completed, complete mobility of the fragment is obtained, and the fragment is repositioned according to plan, a retentive appliance with metal archwires should be fixed to the maxillary teeth to ensure the correct degree of displacement. To obtain greater stability, the repositioned segment is fixed in the new position with a titanium plate attached to the anterior part of the maxilla.

Complications

Various complications are possible. The most serious is undoubtedly osteonecrosis of the repositioned segment, caused by an insufficient vascular bed due to an improper or too-wide mucosal incision during the creation of surgical access. This is a serious event that concludes with the loss of the teeth and the repositioned alveolar bone; this occurrence is, however, very rare.

Another problem that can occur during the surgery is damage to the palatine artery, causing substantial hemorrhage and

an extensive postoperative hematoma; this does not necessarily imply, however, damage to the nutrition of the osseous segment. The result of the surgery can be satisfactory even if the period of convalescence is accompanied by notable discomfort for the patient because of swelling.

The complications that can arise over time involve periodontal damage, loss of sensitivity or vitality of the teeth, and instability of the repositioned segment. Periodontal recession, with partial loss of interradicular bone, can occur in the area where anterior vertical osteotomy is performed. Evaluation of the risk of loss of vitality of the repositioned teeth is interesting. One of the more in-depth studies on this topic⁴⁰ concludes that, if the correct technique is followed during surgery and the apical osteotomy is carried out at a distance of 3 mm from the apex, more than 90% of teeth involved in the surgery will be vital. The instability of the repositioned segment is extremely rare, thanks to the current techniques of rigid fixation with titanium plates.

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8

Principles of Endodontics and Restoration of Endodontically Treated Teeth

Modern endodontics has, in the last few years, been the focus of considerable intellectual discourse. Scientific research and consequent technological progress offer techniques, materials, and indications that are ever more precise and reliable. The therapeutic prospects and the long-term prognosis for success are continually increasing.

Nonsurgical endodontics has benefited from the application of nickel and titanium alloys, and indeed the most recent instruments are constructed in these alloys, which have superelastic qualities; nonsurgical endodontics has also perfected techniques of obturation, with thermoplastic gutta-percha making restoration simpler and more dependable.

Surgical endodontics, which makes use of the operating microscope and extremely precise and biocompatible retrograde obturation materials, has become much less invasive, conserves more tissue, and has an increased success rate.

Over the course of the last few years, all these improvements have allowed the conservation of teeth that would otherwise have been extracted. Restoration of endodontically impaired teeth enables the patient to maintain acceptable esthetics and enjoy satisfactory function.

This chapter explains the scientific fundamentals on which to base decisions dealing with restorative treatment of endodontically treated teeth, in particular for complex prosthetic restorations that call for multidisciplinary treatment, including endodontics.

Selection of Abutments

Endodontics is a preparatory discipline focused on conservative or prosthetic restoration of a tooth. Decisions regarding endodontic treatment and the restoration of a single tooth must be considered in the context of a wider evaluation of all aspects of oral rehabilitation.

The treatment plan involves numerous clinical considerations to evaluate whether a tooth that needs endodontic treatment should be used as a prosthetic abutment. These considerations

can be linked to the diagnosis and prognosis of the endodontic treatment, the individual structures of the endodontically treated tooth, and the type of planned prosthetic restoration, or they can be dependent on the general health of the patient.

Diagnosis and prognosis in endodontics

Planning of endodontic treatment requires a correct diagnosis based on comprehensive knowledge of the parameters for therapeutic success, as well as the clinical and radiographic symptoms and signs of failure. It is not possible to accurately predict every therapeutic possibility, despite an accurate diagnosis. In endodontics, a clinical examination (inspection, palpation, percussion, and periodontal probing) is always carried out in conjunction with a detailed radiographic analysis, the aim of which is to identify indications for root canal treatment. A tooth that is affected by an irreversible pulpal pathosis must be treated endodontically.

The success rate of orthograde treatment has been reported to be between 90% and 95%.¹⁻⁵ Sjögren et al⁶ highlighted the extent to which the pulpal and periapical state prior to the intervention influences the long-term results of endodontic treatment. Indeed, with the treatment of both vital and nonvital teeth, the success rate at 10 years falls from a 96% success rate in the absence of periradicular radiolucency before the intervention to 86% for necrotic teeth that showed periradicular radiolucency at the time of diagnosis. The authors reported the same tendency in cases of nonsurgical endodontic retreatment.⁶

Teeth with no symptoms that have already been treated endodontically and that are destined for prosthetic restoration must also be reevaluated. The factors to be taken into consideration are the distance of the obturation from the radiographic apex, the density of the obturation, the shape and form of the canal (Fig 8-1), and the presence of fractured instrument pieces (Fig 8-2). Friedman and Stabholz⁷ have shown that any tooth with manifest imperfections of one or two of the aforementioned parameters must be considered a potential failure. If

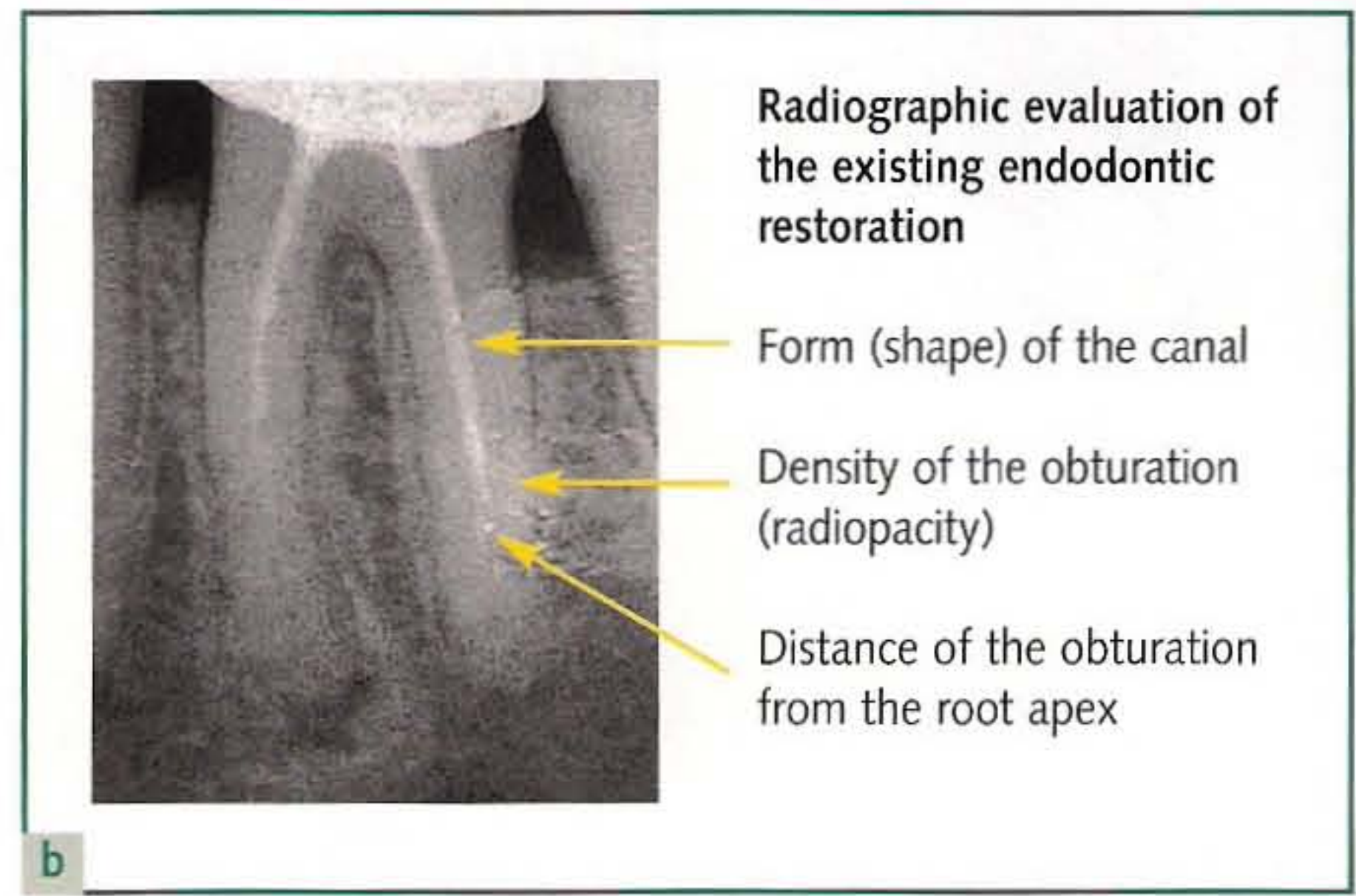


Fig 8-1 (a) Pretreatment radiograph of the mandibular left first molar, destined for prosthetic restoration; (b) evaluation of the need for endodontic retreatment; (c) posttreatment radiograph after endodontic retreatment and restoration.

the tooth is destined to become part of a prosthesis, nonsurgical or surgical retreatment will be suggested, depending on the accessibility of the root canal system. In the case of nonsurgical retreatment, the success rate recorded in literature is comparable to that of orthograde endodontic treatment.⁸

One of the objectives of endodontic treatment is to gain a continuous and progressive taper by shaping the root canal. This is intended to enable optimal cleaning and disinfection with irrigant solutions and a three-dimensional obturation of the root canal system.^{9,10} Nygaard-Ostby and Schilder¹¹ have discovered that it is impossible to sterilize even the simplest root canal systems. In the absence of total cleansing, it is essential to render the bacteria inactive by eliminating their "biologic space" by means of three-dimensional obturation of the complex root canal system (Fig 8-3).

The most frequent causes of failure are incomplete treatment of the root canals, lack of apical seal, placement of the obturation in the presence of moisture, loss of coronal seal, and

fractures, in both the apicocoronal and coronapical directions. Even if the first four causes mentioned can be resolved with orthograde or retrograde retreatment, vertical fracture is not restorable and inevitably condemns the tooth to extraction.

The coronal seal represents a very important predictive factor, even if it has been undervalued in the past. Various authors¹²⁻¹⁶ have shown how infiltration (microleakage) of bacteria and toxins, allowed by an imperfect coronal seal following secondary caries or failure of the cementation of a post or a provisional restoration, can compromise the outcome of endodontic treatment (Fig 8-4). It follows that the preprosthetic restoration with a post or the definitive conservative restoration should be carried out in the shortest time possible.¹⁷

The flowchart in Fig 8-5 can be used to find the most advantageous and effective clinical strategy.

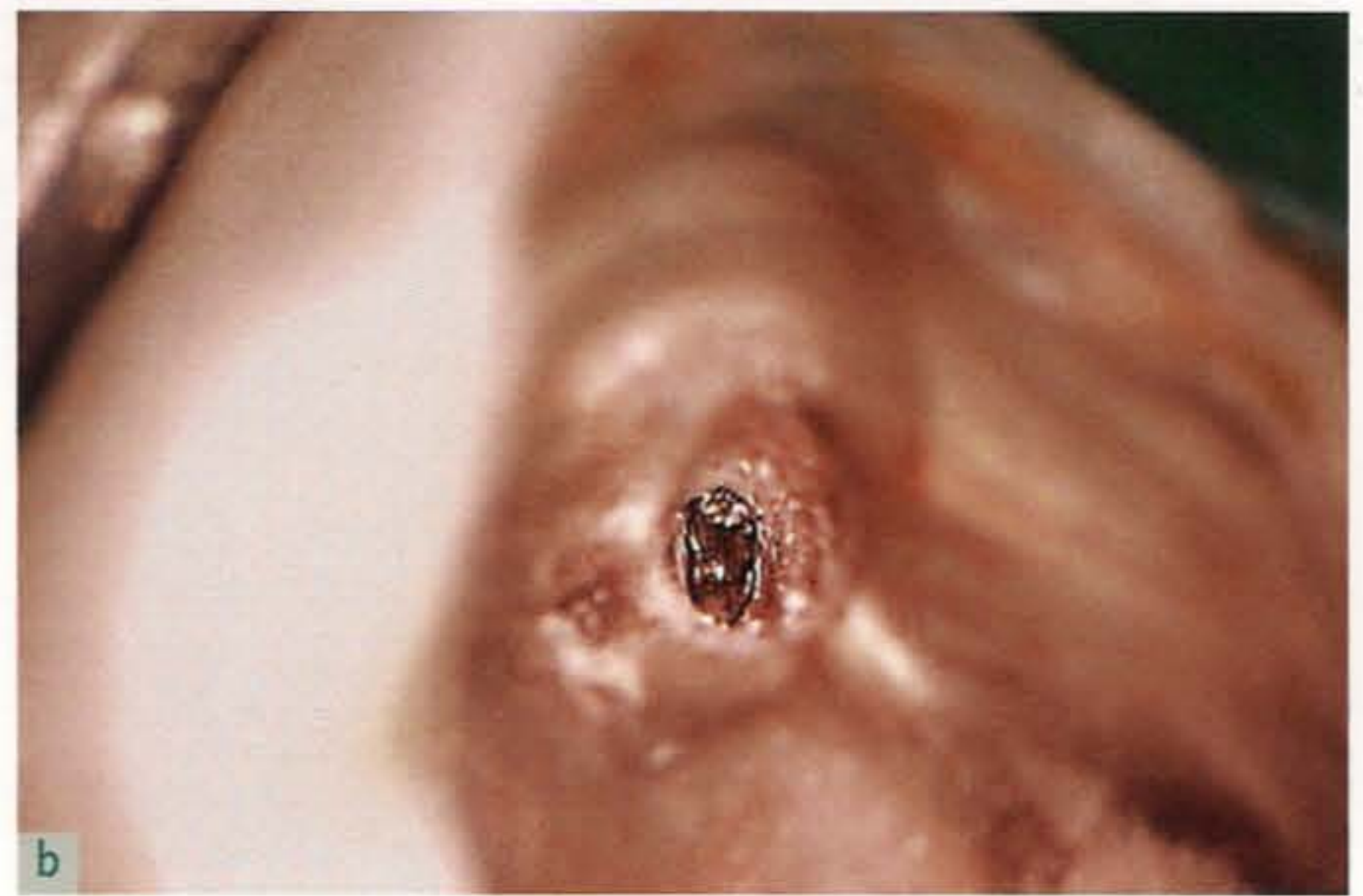


Fig 8-2 (a) A portion of an instrument remains in the middle third section of the mesiobuccal canal of the mandibular left first molar; (b) the residual portion of the instrument is identified by an operating microscope; (c) the instrument is removed; (d) radiograph of the completed treatment. (Courtesy of Dr E. Berutti.)

Fig 8-3 (right) Complexity of the root canal system in a first mandibular molar. (Courtesy of Dr W. Hess.)

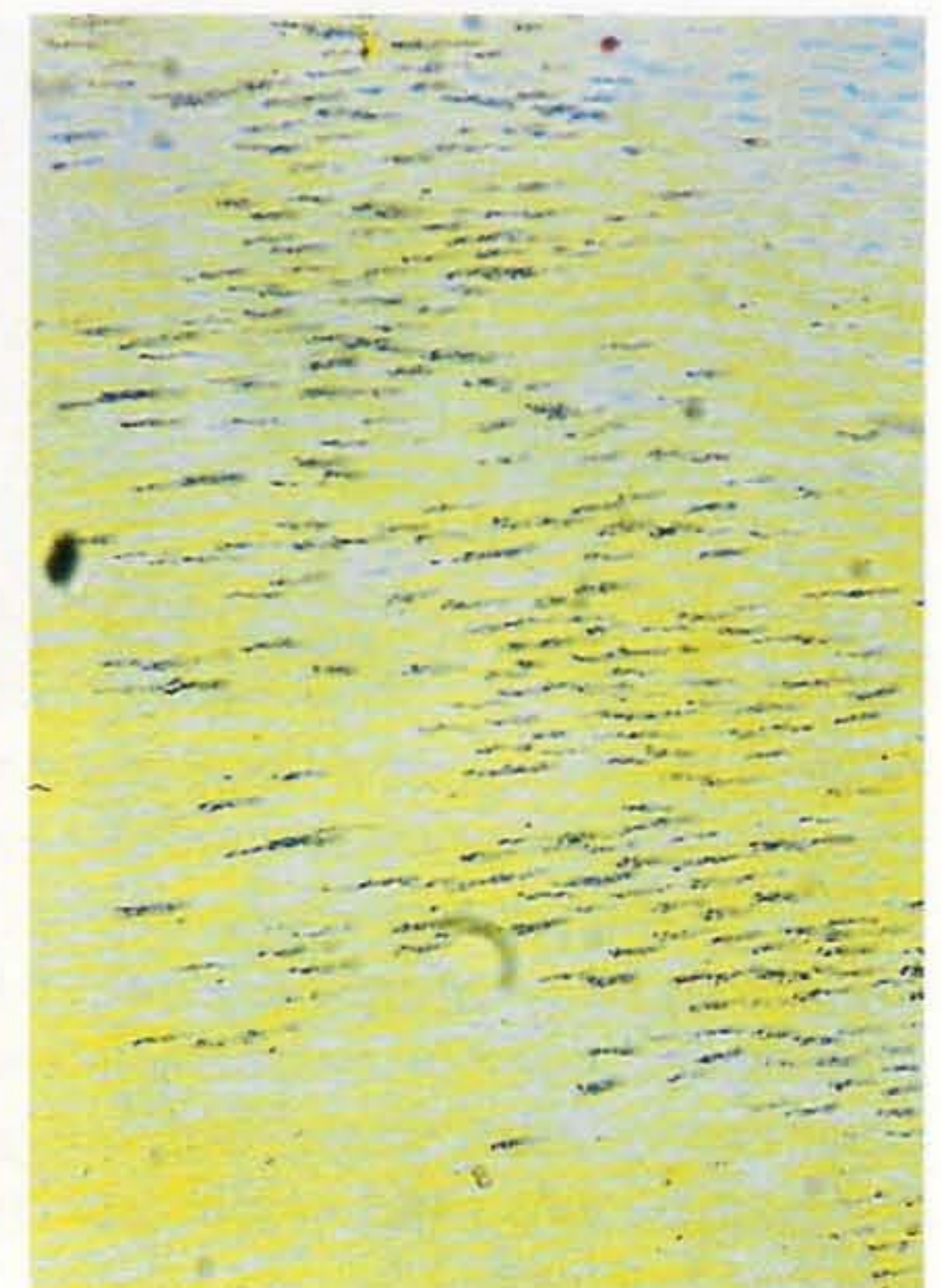
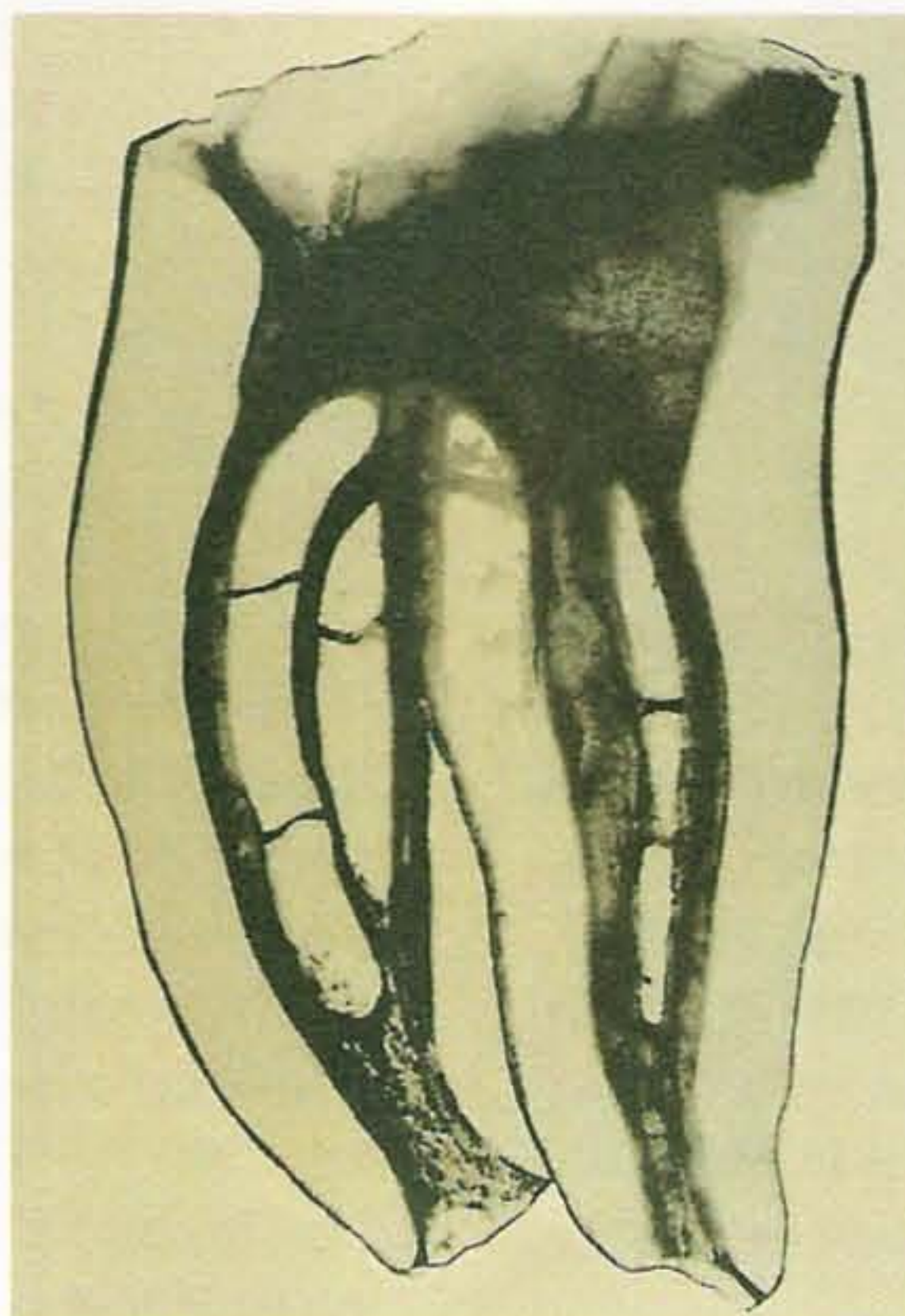


Fig 8-4 (far right) Infection of dental tubules as viewed through a microscope. (Brown-Brenn staining.)

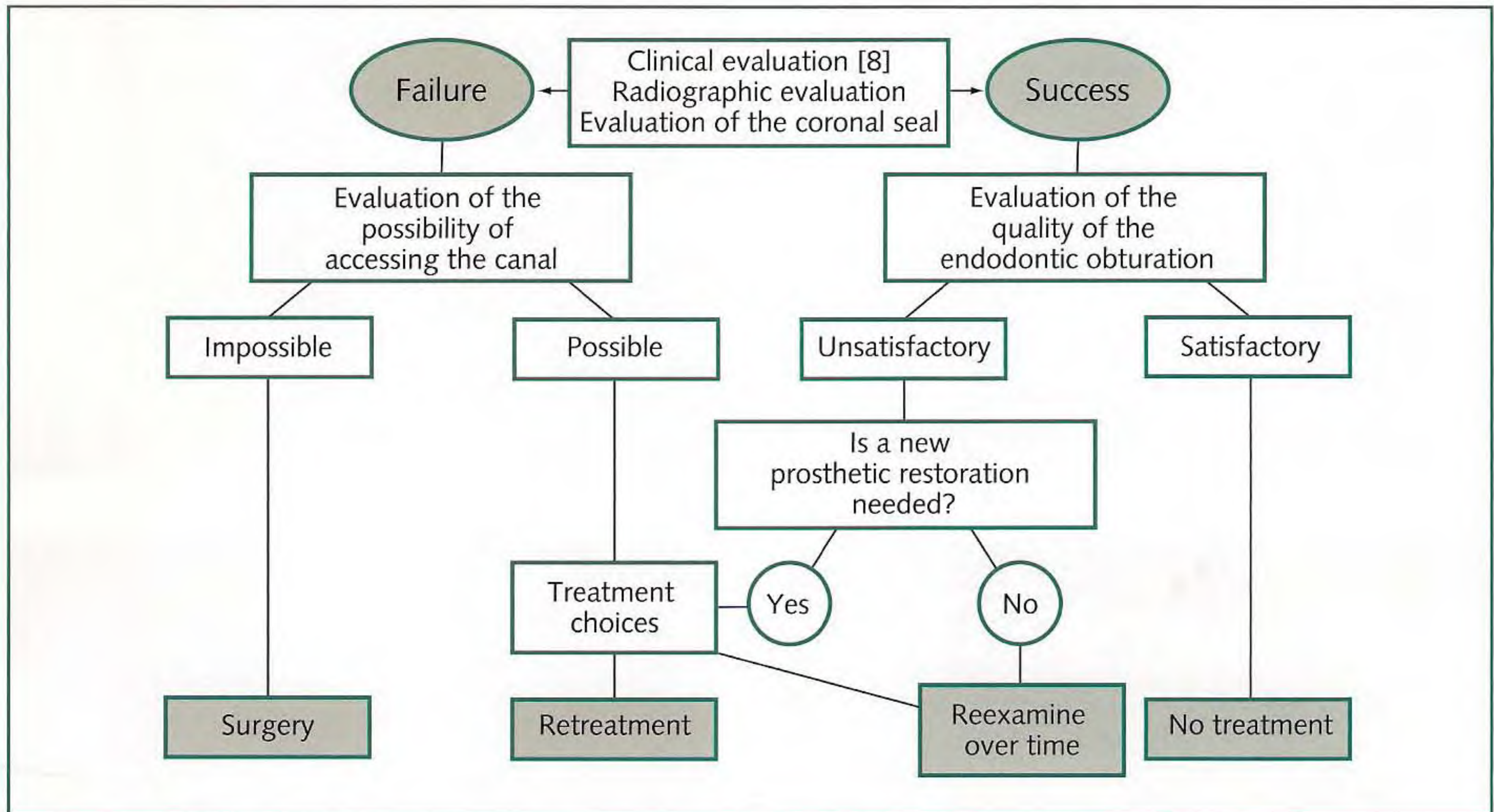


Fig 8-5 Indications for endodontic retreatment. (Adapted from Friedman and Stabholz.⁷)

Characteristics of endodontically treated teeth

An endodontically treated tooth is considered less resistant to mechanical stress than a vital tooth.¹⁸ There are various hypotheses about the causal factors. Helfer and others¹⁹ have reported diminished hydration of the dentin of endodontically treated teeth, which would make the tooth more fragile. The hardness, because of reduced mineralization, is also inferior to that of vital teeth.²⁰

A principal role is attributed to the quantity of residual tooth substance. Teeth that need endodontic treatment usually have already suffered a marked reduction in the coronal aspect because of caries or significant conservative and prosthetic restoration. Root canal treatment and successive restoration with posts require removal of root dentin and further reduce the quantity of dental tissue (Fig 8-6). The result is a tooth that, even if morphologically restored, does not present the same characteristics of mechanical resistance as a vital tooth. Various studies²¹⁻²⁴ have shown a direct correlation between the residual quantity of dentin and the resistance to fracture. Thanks to these studies, it can be reasonably inferred that the prognosis for an endodontically treated tooth will be better in direct proportion to the amount of remaining tooth structure, both coronally and radicularly (Fig 8-7).

Prosthetic planning

The anticipated prosthetic design influences the decision of whether or not to restore a tooth that has endodontic problems. Complete coronal prosthetic restoration of an endodontically treated tooth is not always suitable. Sorensen and Martinoff²⁵ have retrospectively analyzed, over a period of 1 to 25 years, some 1,273 endodontically treated teeth. The survival of teeth restored with a crown or coronal onlay (Fig 8-8) has been compared to that of other teeth that have been restored with simple obturations. For incisors and canines, the results suggested that a crown did not increase the durability and that therefore a simple restoration of the endodontic access hole would have been adequate for teeth that had sufficient integrity. In the case of premolars and molars, on the other hand, the presence of a coronal prosthetic restoration significantly increases the survival of the teeth (Fig 8-9).

Another factor of great importance is the eventual use of the endodontically treated tooth as an abutment for a fixed partial or removable prosthesis, because of the probable increase in the load to which the tooth would be subjected. Some studies have documented a lower success rate for abutment teeth than for single teeth.^{25,26} The use of endodontically treated teeth as distal abutments for a fixed cantilever prosthesis is most certainly contraindicated because the increased likelihood of fracture²⁷

Fig 8-6 (*right*) The maxillary left second premolar is restored with an indirect post. There is a longitudinal fracture of the root.

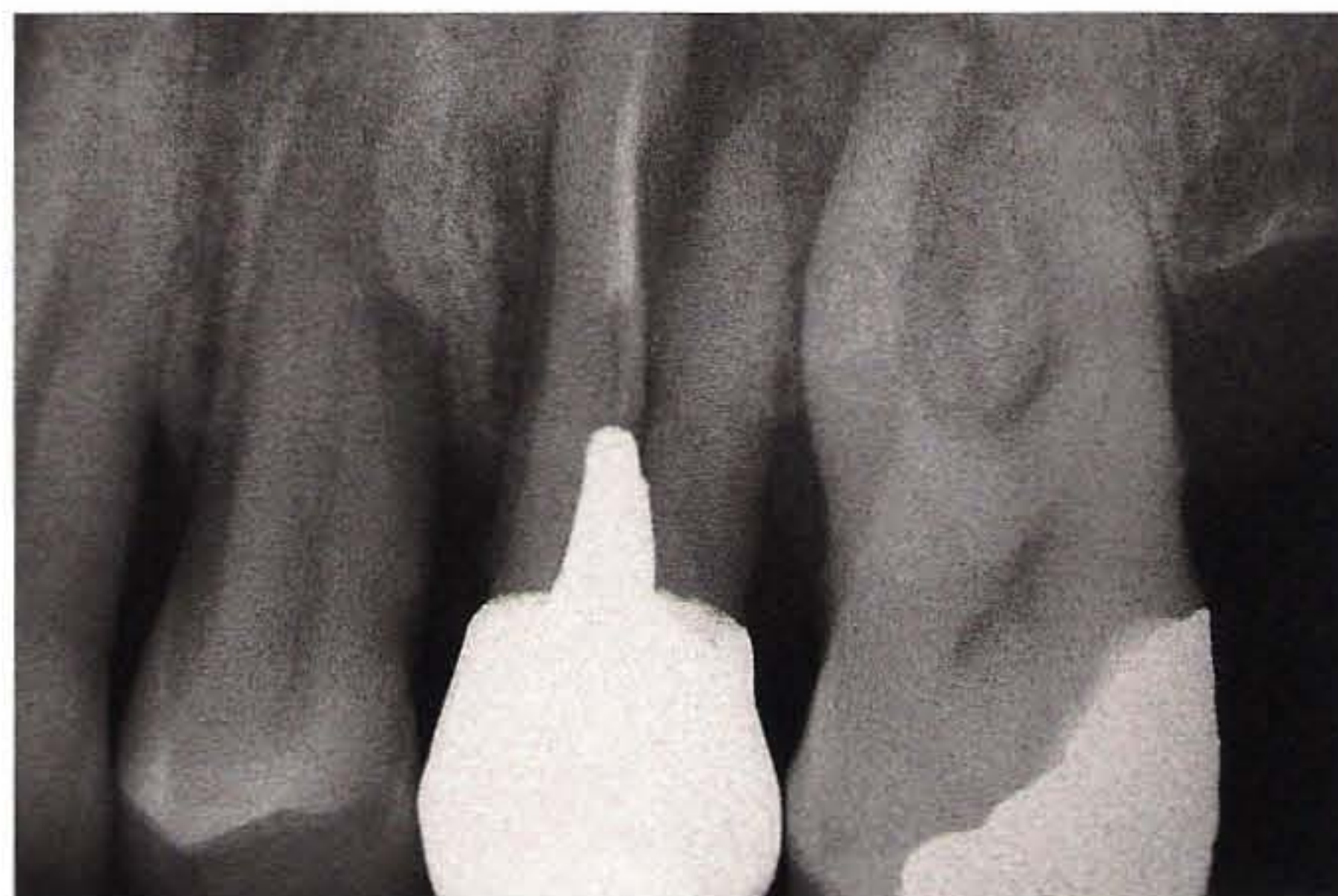


Fig 8-7 (*below*) (*a and b*) The remaining dental structure of the maxillary right second premolar permits a restoration with a good long-term prognosis.

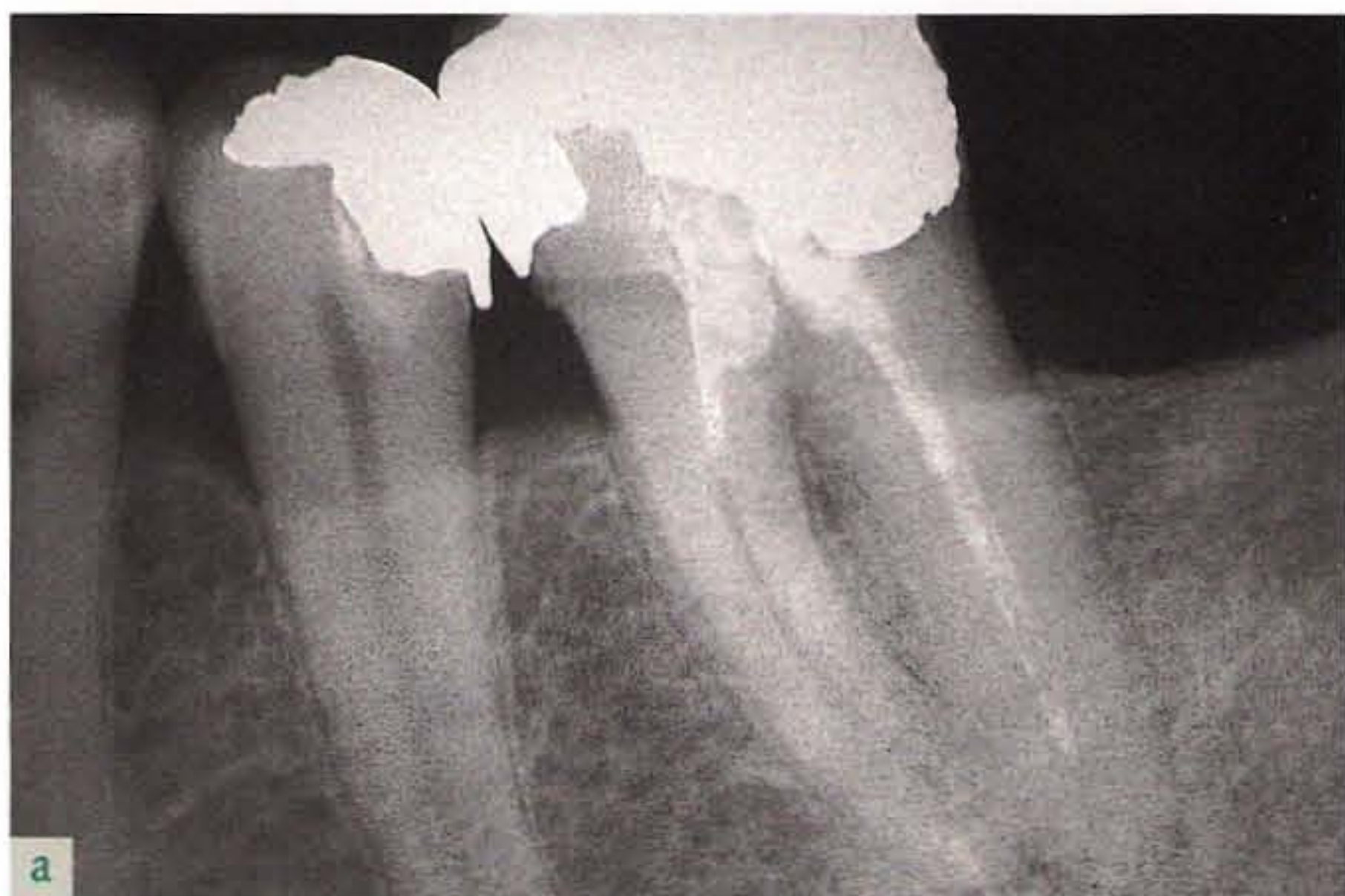


Fig 8-8 (*a*) Pretreatment radiograph of the mandibular left second molar, which is to have endodontic retreatment; (*b*) radiograph after endodontic retreatment and restoration with a gold-ceramic crown.



Fig 8-9 Coronal fracture of the mandibular right first molar, treated endodontically and restored with amalgam.



Fig 8-10 The mandibular right second premolar is used as a distal abutment for a fixed cantilever prosthesis. There is a longitudinal fracture of the root.



Fig 8-11 (a and b) The maxillary left second premolar, a single tooth with a doubtful prognosis, can be prosthetically and endodontically restored, although with difficulty.

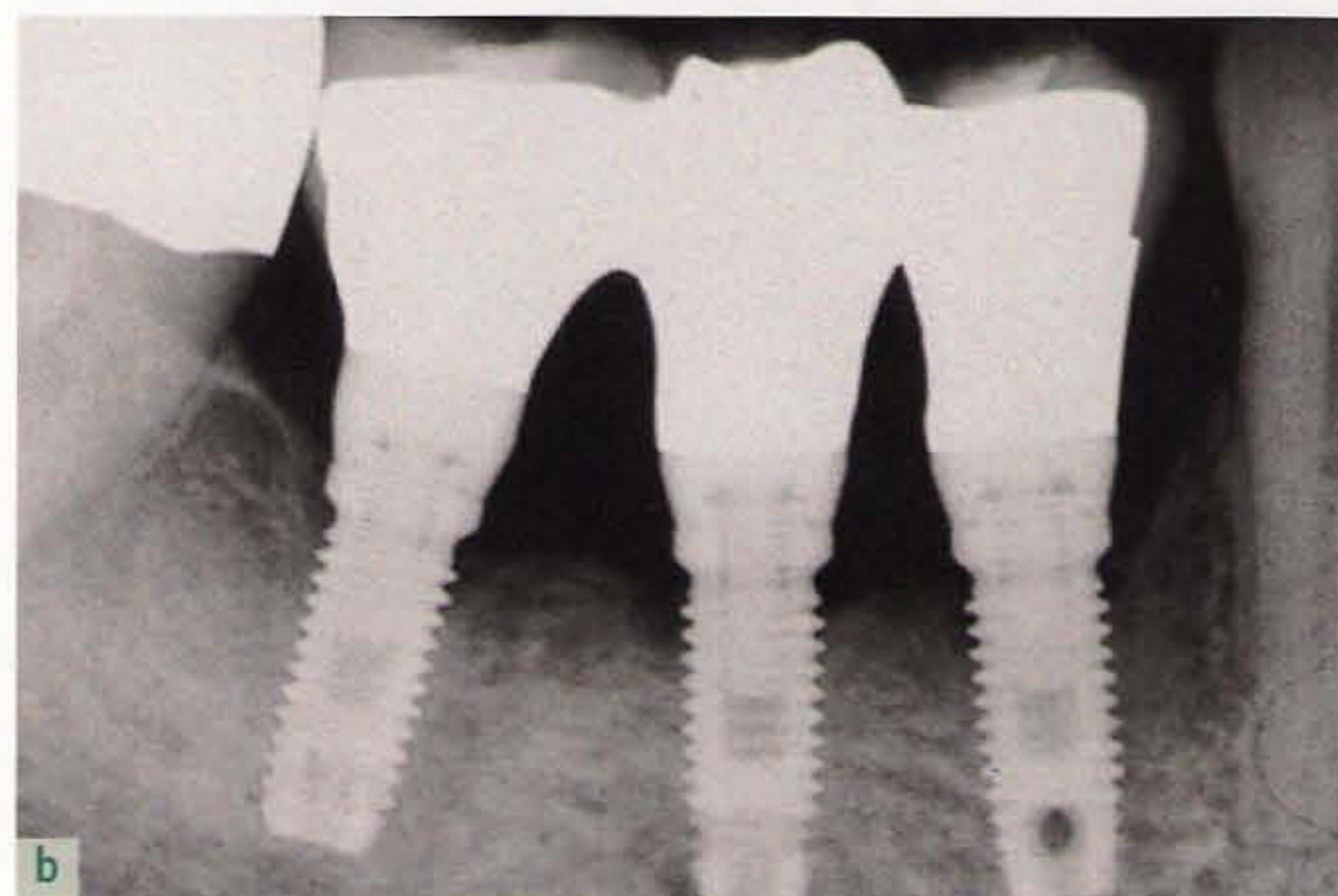
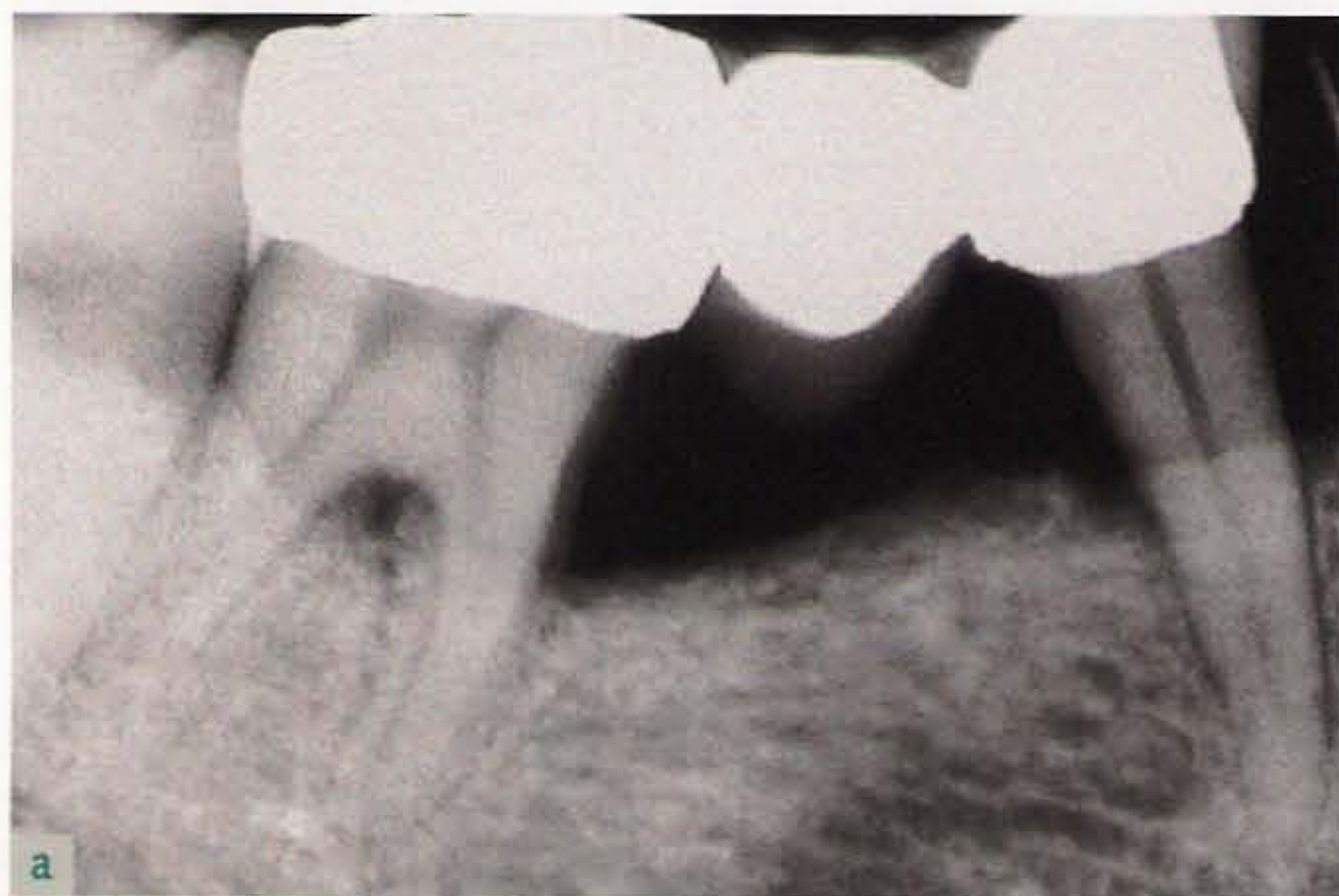


Fig 8-12 (a) The mandibular right second premolar and second molar have uncertain periodontal prognoses; (b) an implant-supported solution has been used in this case.

(Fig 8-10). A low success rate has also been shown in the case of endodontically treated teeth in occlusion with arches restored with a fixed prosthesis as opposed to arches rehabilitated with a removable prosthesis.²⁸

There is no substitute for clinical judgment based on scientific knowledge when it comes to creating a correct treatment plan. In an undamaged mouth, a tooth with an uncertain endodontic prognosis but that is destined for a single-crown restoration is a candidate for recovery, even if this proves difficult (Fig 8-11). The same tooth, if used as an abutment for a fixed prosthesis or an anchor for a removable prosthesis, does not guarantee the same possibility of endurance. In light of results achieved with implants, it is always advisable to carefully evaluate the possibility of success of endodontic therapies that may be complicated and prognostically doubtful, because implants are very reliable in the long term (Fig 8-12).

General factors

All these local factors must be considered together with general characteristics of the patient who is to be treated. In patients with compromised general health or with socioeconomic problems, the endodontic treatment and restoration of a tooth is conditional on the absolute need to use it as an abutment, the predictability of the result, and the simplicity of the therapy.

The majority of systemic diseases do not contraindicate endodontic treatment.²⁹ It is, however, the clinician's duty to carefully evaluate the general clinical conditions and weigh the risks and benefits before subjecting the patient to any type of treatment. For example, for a patient who has to undergo an imminent organ transplant, multiple endodontic retreatments should not be planned, and the intervention strategy will probably be less conservative and involve strategic dental extraction.

Restoration

Once it has been decided that the tooth will be subjected to endodontic treatment, it is necessary to establish in what manner it will be restored. While the scientific and qualitative standards of endodontic therapy are consistently accepted, there is no consensus on which technique is the best in terms of restoration of these teeth. This uncertainty is due to the lack of adequate experimental research dedicated to this topic.³⁰ Until the 1970s, the very little literature that was available presented techniques based exclusively on individual experience. More recently, a great number of in vitro studies have been published, the scientific value of which, however, is limited by the experimental method. Unfortunately, even today there are very few clinical studies, and prospective studies are even fewer. For this



Fig 8-13 The mandibular left canine has been restored with an indirect post that is as long as possible in relation to the root anatomy.

reason, the scientific information on which to base restoration of endodontically treated teeth is limited and often contradictory.

Characteristics of post and core restorations

In the vast majority of cases, endodontically treated teeth are restored with a post and core restoration. Numerous studies of indications for clinical use have analyzed the characteristics that are essential for their long-term survival (that is, retention and resistance to fracture).

The retentive qualities of a post seem to be directly linked to its length, even if there are no clear indications as to the ideal dimensions. Some authors suggest a length that is equal to that of the clinical crown^{25,31-33}; others suggest that it be more than 50% longer than the crown³⁴; and others suggest half³⁵ or two thirds the length of the root.³⁶ On the basis of this research and the fact that every tooth must be analyzed individually because of its individual anatomic morphology, a post should be as long as possible (Fig 8-13),³⁷ without compromising the seal obtained with the root canal filling. Various authors have suggested that at least 4 to 5 mm of gutta-percha³⁸⁻⁴¹ be maintained apically.

The diameter of a post does not have a significant effect on increasing retention.⁴² It does seem, however, that the greater the diameter, the greater the risk of fracture because of dimin-



Fig 8-14 (above left) Preprosthetic restoration with an active post in the distal root of the mandibular left first molar.

Fig 8-15 (above right) Preprosthetic restoration with a passive titanium post, cylindrical and milled, in the palatal root of the maxillary right first molar.



Fig 8-16 (left) The maintenance of 2 mm of residual tooth structure contributes to and augments the resistance to fracture of the tooth-restoration unit.

ished residual tooth substance.⁴³ To preserve dentin and avoid perforations, the diameter should be as small as possible but should never be greater than one third the diameter of the root^{44,45} and, at the tip, should not measure more than 1 mm in diameter in the majority of teeth.⁴⁶

Various forms of posts have been proposed in literature. Those that are active (Fig 8-14), ie, screwed inside the root, offer the best retention^{42,47,48} but are also the cause of considerable stress, which increases the risk of fracture.⁴⁹ In the case of cemented posts, a cylindrical form offers greater retention than a conical form, as does a milled surface with respect to a smooth surface^{42,48,50} (Fig 8-15).

Another factor that seems to contribute considerably to resistance to fracture of the endodontically treated tooth is presence of at least 1 to 2 mm of residual coronal dental structure, which allows the crown to exercise an adequate splinting effect⁵¹⁻⁵³ (Fig 8-16).

Indirect restorations

Indirect restoration, that is, with cast posts and cores (Fig 8-17), is the method that has been used for the longest time when it comes to restoration of endodontically treated teeth.^{28,54,55} The advantage of cast posts is their capacity to adapt to the remaining tooth structure, unlike prefabricated posts, for which preparation with dedicated burs can be contraindicated in teeth that are already compromised.⁴⁶ The clinical validity of this technique is sustained by some retrospective clinical studies (Fig 8-18). In a 6-year study on 96 cast posts used as abutments for fixed partial prostheses and single crowns, Bergman and others²⁸ found a 1.5% failure rate each year. Analyzing 138 cast posts over 10 years, Weine and others⁵⁶ noted nine failures, two of which were fractures. By comparing two designs of cast posts on a total sample of 788 over 4 to 5 years, Torbjörner and others⁵⁷ reported a total failure rate of 8% and suggested that a cylindrical morphology was superior to a traditional one.



Fig 8-17 (a) Appearance at the time of removal of a poorly fitting fixed prosthesis; (b) appearance after endodontic retreatment and restoration with indirect gold alloy posts.



Fig 8-18 (a) Clinical case in 1968, the preimplant era; (b) the same case, 29 years later. (Courtesy of Dr B. Bresciano.)

Direct restoration

Direct restorations are those that are performed in one sitting, with or without the use of a prefabricated root post. In the past, some authors maintained that it was always necessary to insert a post in the root of an endodontically treated tooth, hypothesizing an increase in resistance to fracture.^{54,58} Other studies have contradicted these hypotheses and limit the role of the post to a simple root anchor of the abutment.^{59,60} In the presence of adequate residual coronal substance, as is often the case in molars, a restoration of amalgam or resin composite (Fig 8-19) seems to be sufficient to guarantee adequate survival.^{53,61,62}

Numerous types of prefabricated posts are available to the clinician. In addition to the older steel posts or more recent titanium posts, new materials have been proposed for direct restoration with adhesive cement. In the early 1990s, to address the problem of the difference in rigidity between metallic posts and teeth, carbon-fiber posts were introduced⁶³ (Fig 8-20); these are made up of 64% longitudinal fibers immersed in a

matrix of epoxy resin. These have about the same elastic modulus as dentin⁶⁴ and should diminish the risk of fracture because of a more homogenous distribution of stress,^{65,66} even if more recent studies do not seem to completely confirm this hypothesis.⁶⁷ One of the advantages of the carbon-fiber posts, which can be attributed to their elastic reaction under occlusal load, is their tendency to become uncemented rather than to fracture in the case of failure.^{68,69}

For esthetic reasons in the anterior segments, because cast posts do not allow an optimum result under ceramic restoration, glass-fiber (Fig 8-21) and zirconium^{70,71} posts have been introduced. These have translucent characteristics and a color that is compatible with the residual dental structure. To date, there are no long-term clinical studies that show the efficiency of these new restorations. From initial short-term retrospective data,⁷² it can be hypothesized that they might have a future as a valid alternative to traditional techniques.



Fig 8-19 The mandibular left first and second molars exhibit residual tooth structure that permits a resin composite preprosthesis restoration.



Fig 8-20 (a to d) Preprosthesis restoration with carbon-fiber posts.



Fig 8-21 (a and b) Preprosthesis restoration with glass-fiber posts.

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Dental Implants: New Opportunities and Clinical Considerations

Over the last 20 years, osseointegrated implants have come to the foreground in current clinical practice; today they constitute an integral part of prosthetic therapy for patients who are partially or totally edentulous.¹⁻⁹

Osseointegration is a fundamental supposition for successful implant therapy; research and clinical application have over the years produced two distinct definitions of osseointegration, one of a histologic nature and the other of a clinical nature. The first describes osseointegration as the acquisition of direct contact between bone and implant, without the interposition of the soft tissues,^{6,7,10,11} evident at the level of optical microscope resolution. Histologic inspection is not possible without sacrificing the implant, however. The clinical definition, which is empirical but certainly more practical, describes osseointegration as a process that creates a rigid and clinically asymptomatic fixation of alloplastic materials in the bone and maintains that fixation during functional loading.¹² The histologic nature of the two distinct interfaces,¹³ that between soft tissue and titanium and that between bone and titanium, has now been investigated in depth.^{14,15} The long-term validity of implant therapy has also been widely documented, confirming the high predictability and reliability of some implant systems.⁶⁻⁹

In 1981, Albrektsson et al¹⁶ specified the composition of the implant (titanium), the form of the implant (cylindrical), the type of surface, the condition of the implantation site, and the surgical technique as factors affecting the acquisition of osseointegration. At the beginning of the 1990s,¹³ some authors agreed on the fact that surgical technique has a role of primary importance in the acquisition of osseointegration, regardless of the type of surface used. Nevertheless, as clearly indicated from the publications of the first long-term results on the survival of the implants,¹ osseointegration is a reversible process, and both failure to achieve direct contact between bone and implant and the loss of this contact can bring about treatment failure. For this reason, research has been concentrated on the evaluation of the risk factors that determine early failures (lack of integration) and late failures (loss of integration after prosthetic loading) of the implant.

As a consequence, some aspects of restoration, beyond simple mechanical stability of the integrated implant, have acquired growing importance to the point that they have become the main research area over the last 10 years. It is understood that not only surgical technique is important but also how quickly osseointegration is acquired, as well as the extent of the osseointegrated surface. A study of treated implant surfaces is therefore today considered to be of primary importance and is reviewed in this chapter. As far as delayed failure is concerned, research has been concentrated on the analysis of the biomechanical aspects of prosthetic restoration and the necessity of taking these requirements into consideration when surgery is planned.¹⁷ Therefore, this chapter will review prosthetic planning through an evaluation of the most appropriate radiographic examinations. Among the biomechanical aspects, masticatory surfaces and occlusal morphology will be considered, as well as the way in which the masticatory load is transmitted to the implants in relation to their number and their arrangement, the possibility of connecting tooth and implant if the clinical need exists, and the connection method of the prosthesis to the implants.

The second part of the chapter deals with the physiopathologic aspects of postextraction bone resorption that affect the design of the implant-supported prosthesis and the simplest to the most complex relevant surgical techniques. These last procedures are within the scope of responsibilities of the maxillofacial surgeon, to whom the clinician should turn during prosthetic planning when very motivated patients have extremely unfavorable anatomic conditions.

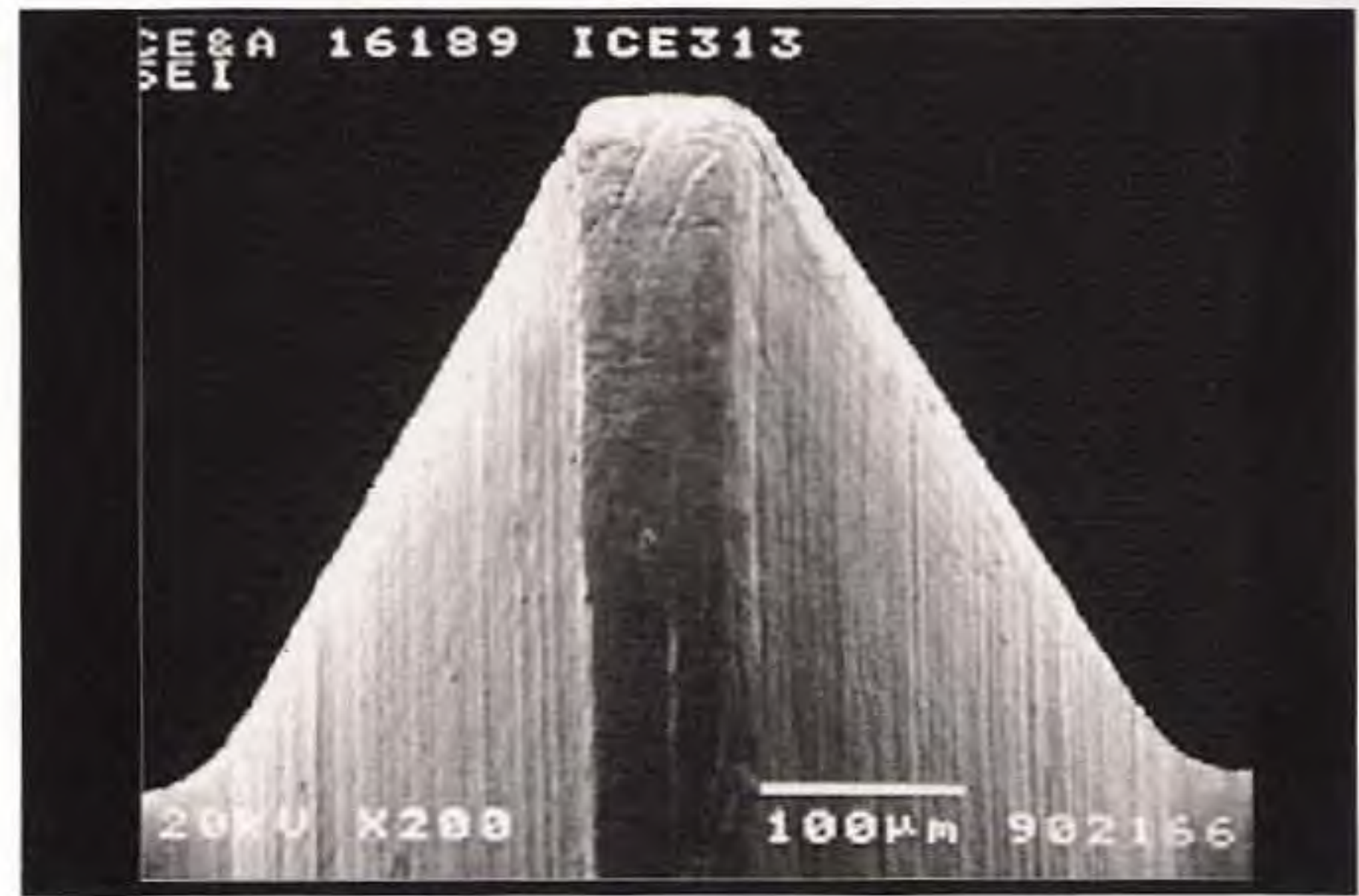
In the third part of the chapter, the histologic and clinical aspects of the surrounding soft tissues are evaluated, the stability and integrity of which are today considered indispensable conditions for the longevity of implant restorations.

The chapter concludes with some considerations of techniques of restoration by means of immediate loading of implants.

Fig 9-1 Screw implant with smooth surface.



Fig 9-2 Microscopic examination of a smooth surface. Note the circumferential horizontal striations.



Implant Surfaces

As always occurs in any scientific field, even in the field of osseointegration, the profession has passed from the study of the phenomenon itself to an attempt at modifying it according to the needs of practice. In the attempt to acquire a more extensive and quicker integration, research has concentrated on the healing procedure and on adhesion between bone and titanium surfaces, making use of the most recent biochemical and biologic-molecular techniques. The characteristics of the surface of the implant have been recognized as having a role of primary importance.

Not long ago, all the data were based on the clinical use of implants made of commercially pure titanium with machined surfaces, generally defined as being smooth (Fig 9-1). With these surfaces, the waiting period for osseous healing after the placement of the implant is 3 months in dense (mandibular) bone and 6 months in spongy (maxillary) bone. It was believed that an insufficient healing period would bring about movement and failure of the implant because of possible overloading of the surrounding bone^{6,7} while the bone-titanium contact was still insufficient.

Research in the following years has concentrated on studying and understanding the biology of osseointegration. New biologic concepts have allowed the initial protocols to be modified with undeniable clinical advantages. A fundamental contribution has been the development of treated, or so-called active, surfaces: titanium plasma-sprayed (TPS) or hydroxyapatite (HA) surfaces, sandblasted and/or etched surfaces, and porous surfaces.

Histologic and histomorphometric studies carried out in animals¹⁸ and humans¹⁹ have shown a positive correlation between the microtopography of the implant surface and the contact between bone and titanium. In these studies, the contact between bone and titanium was evaluated by comparing

implants with smooth and treated surfaces. The results showed that surface-treated implants obtained a superior bone-titanium contact and that a smaller interval of time was necessary for its formation. These studies have important clinical implications because they show that the use of treated surfaces can reduce the healing time and increase the resistance to the functional load.

To understand how surface treatment can influence the phases of bone healing, it is necessary to analyze the possible procedures of conditioning the surface of the implant. As mentioned before, the first surface used was the one mechanically treated during the turning of the implant, generally defined as being smooth. Under inspection with a microscope (Fig 9-2), this surface shows circumferential horizontal striations produced by drills during the process of turning. These striations vary, depending on the protocol of the manufacturer, the degree of hardness of the titanium used, and the sharpness of the rotating instruments, but they are always less than 1 µm in width. Such surfaces can today boast the largest number of both experimental and clinical studies, and long-term results prove their validity.^{7,8} These studies have affirmed that this type of surface reaches its greatest potential when used in the presence of dense bone with a healing time of more than 3 months.⁸ This surface treatment guarantees, furthermore, the best relationship between titanium and the surrounding tissues.

Smooth surfaces have shown their limits in the presence of spongy bone: The success rate in the maxilla or in the presence of spongy bone shows a great difference with respect to that of the same implants placed in dense bone or implants of small dimensions.^{20,21}

The first surface treatments used were TPS and HA-coated surfaces. The TPS treatment consists of soldering drops of metal fused at high speed on the surface of the implant, obtaining a veneer with a thickness that varies from 10 to 40 µm. In the HA treatment, the implant is coated with HA particles with a thick-

Fig 9-3 Microscopic examination of a coated surface. Note the macroroughness, which is distributed in a nonhomogenous manner.



Fig 9-4 Microscopic examination of a coated surface. (circled areas) Zones of microdetachment are evident in the coating.

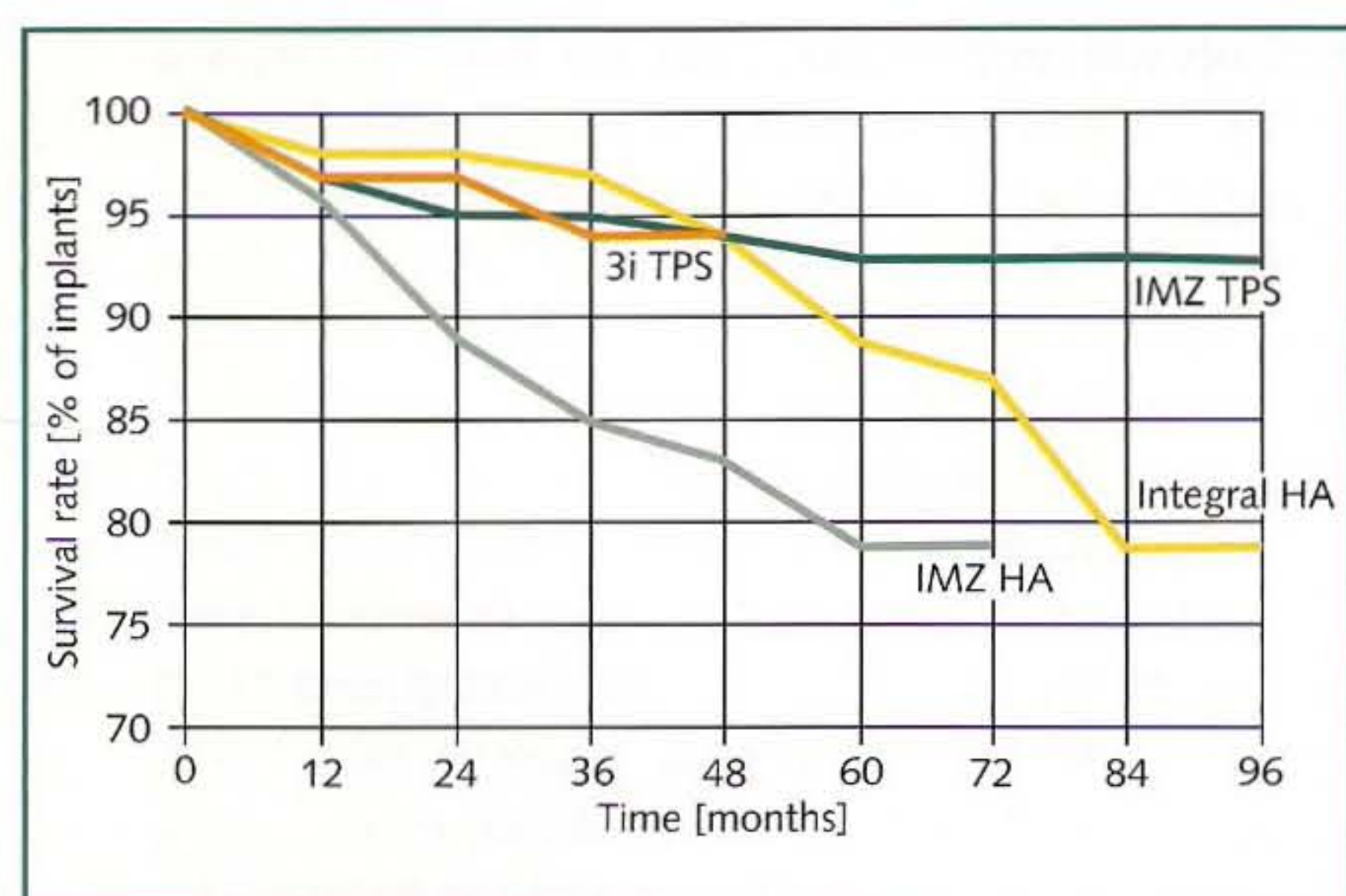
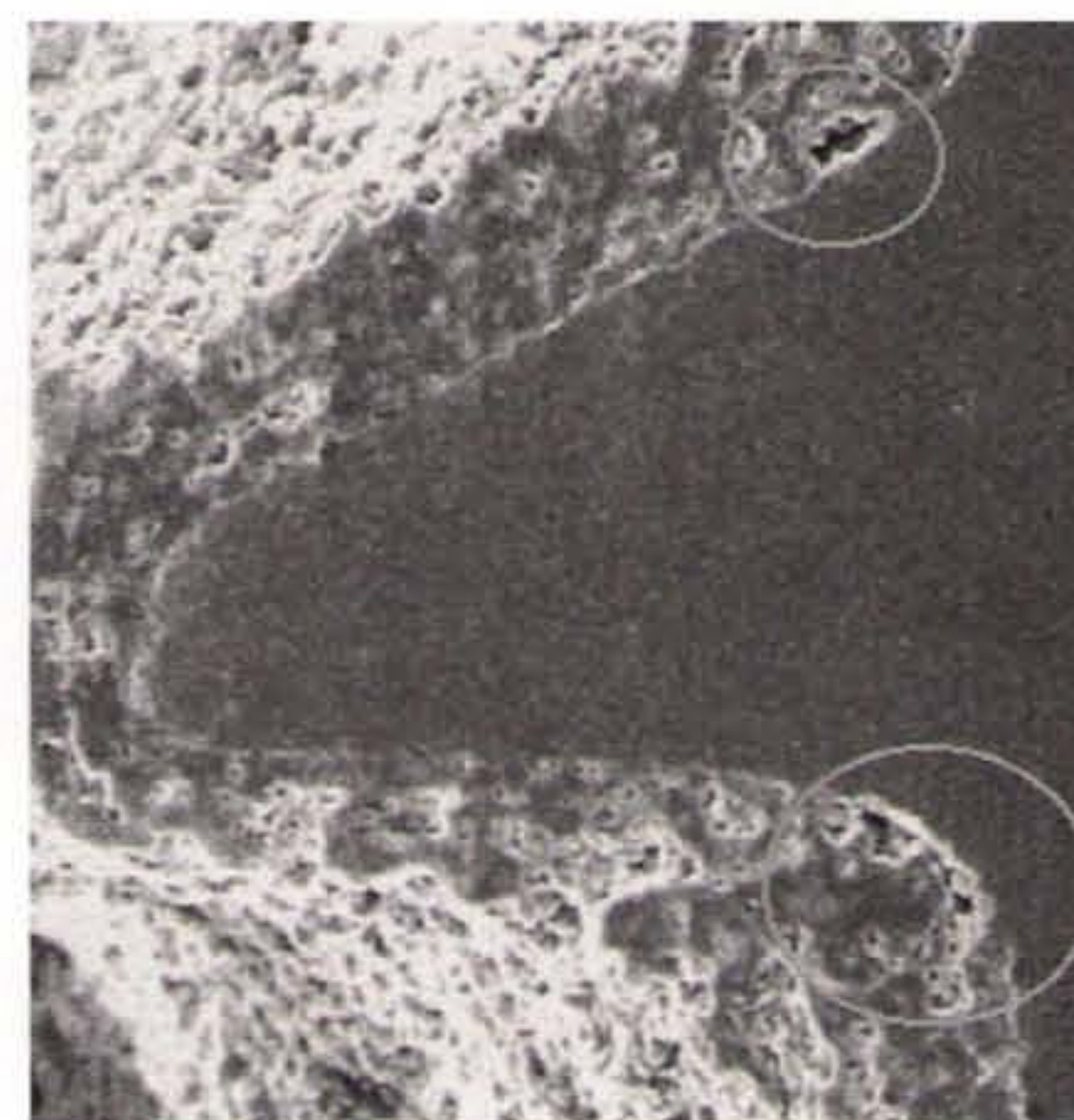


Fig 9-5 Survival rates of smooth-surface implants and HA-coated implants. The latter shows a high percentage of failure after prosthetic loading. (From Wheeler.²³ Reprinted with permission.)

ness of 70 μm (Fig 9-3). These treatments allow preparation of surfaces defined as rough. The average roughness is 1.82 μm for TPS implants and varies between 1.59 and 2.94 μm for HA-coated implants.

Greater bone-titanium contact can be obtained with this type of surface than with a smooth surface. (Table 9-1): It would be rational to suppose that these porous surfaces increase the fixation and the stability of the implant as a result of the greater mechanical interlocking created between the surface of the implant and the surrounding bone.²² The treatment for adhesion of HA can create local microdetachments of the coating and consequent loss of integration²³ (Fig 9-4). This type of very rough surface is associated with rapid bone destruction if the implant surface becomes exposed to oral microflora: This explains the high percentage of failure, after loading, of coated implants²³ (Figs 9-5 and 9-6). The TPS and HA-coated surfaces are today considered very rough surfaces;

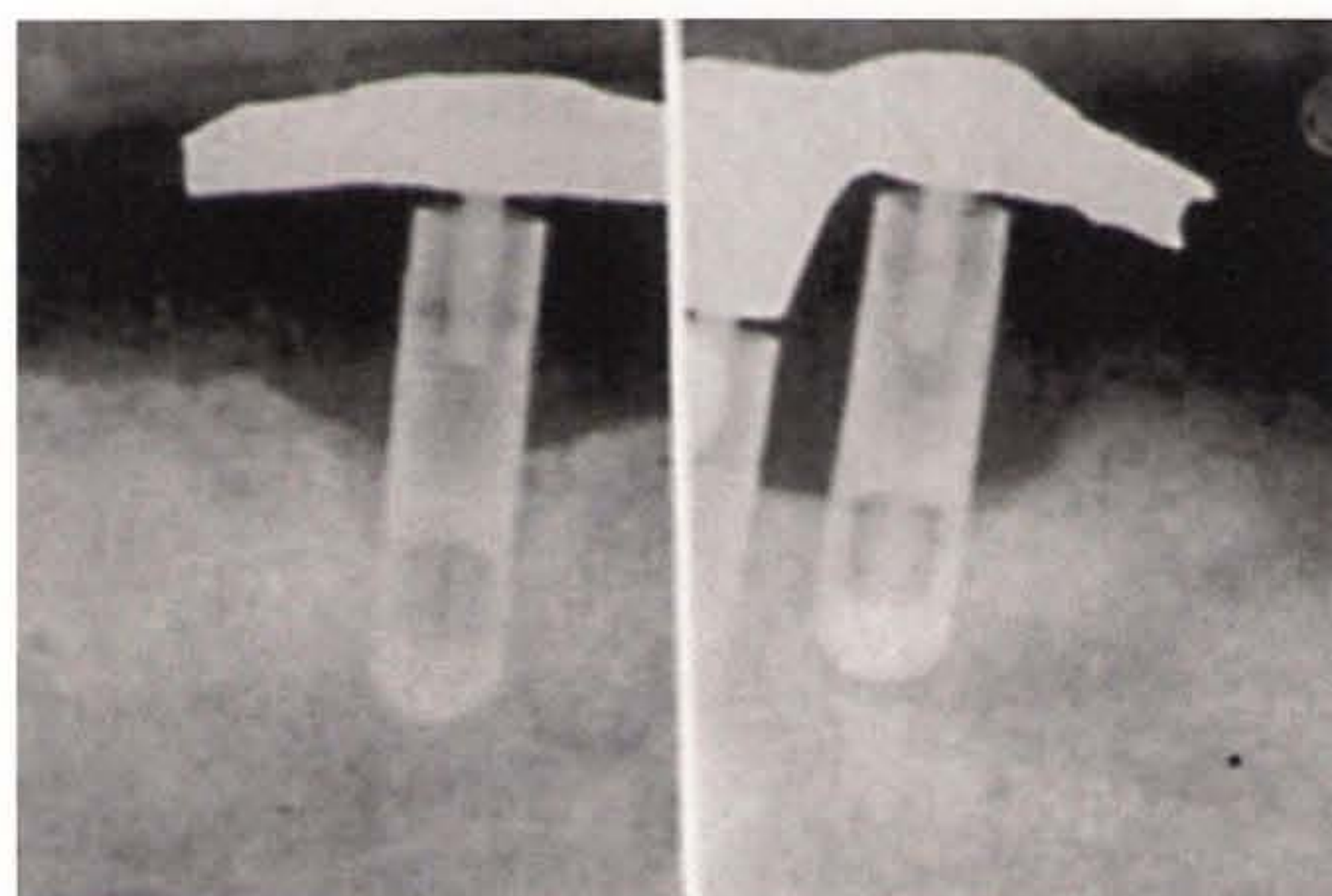


Fig 9-6 Radiographic examination of a coated implant. There is evidence of peri-implant bone loss after prosthetic loading.

Table 9-1 Percentage of contact between bone-titanium with different surface treatments

Type of surface	Contact
Machined	30%–40% ¹
Titanium plasma-sprayed	40%–50% ^{24,25}
HA-coated	60%–70% ^{24,25}
Acid-etched (Osseotite)	72%–77% ¹

Wennerberg et al^{24,25} have shown that there is no linear correlation between the roughness of the surface and the level of osseointegration.

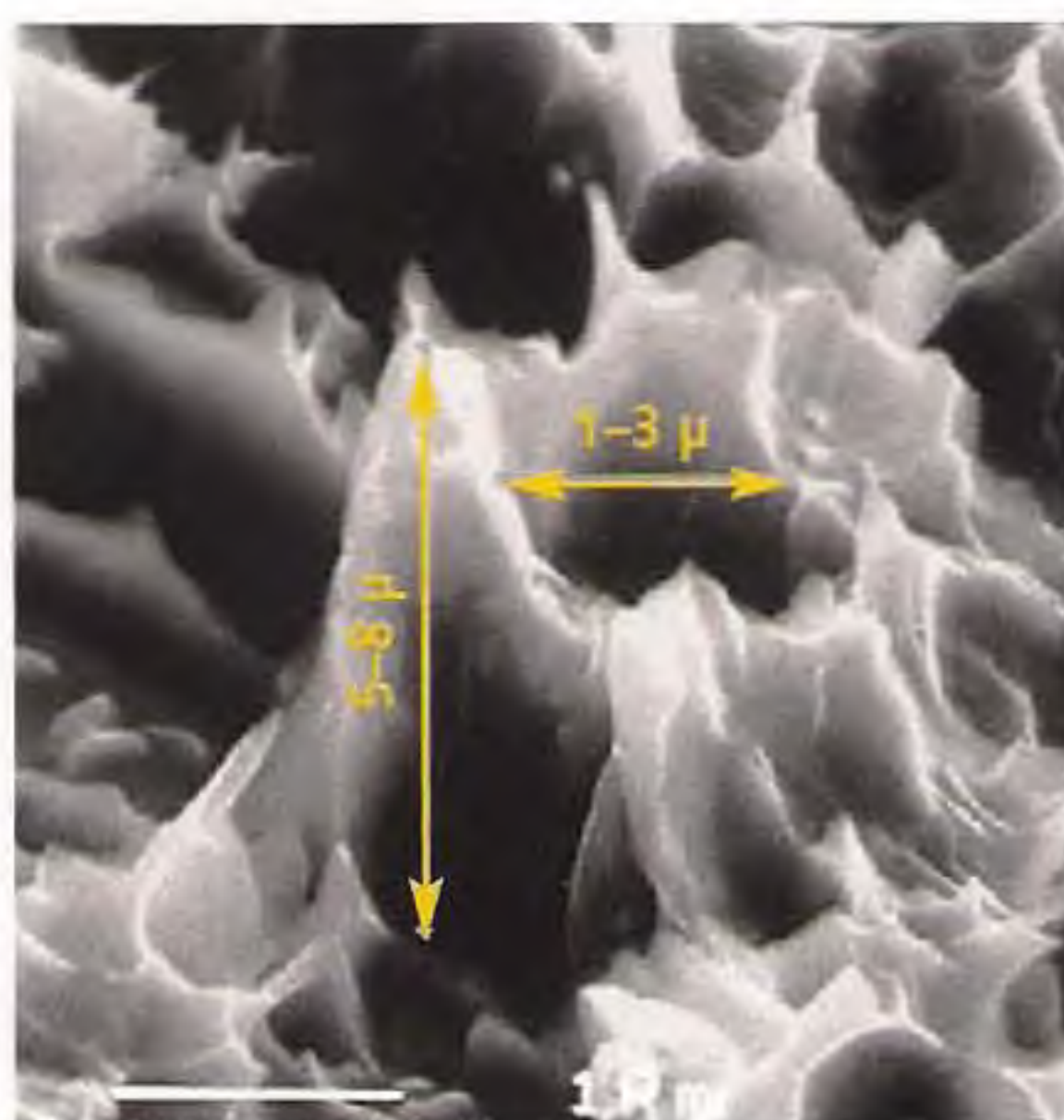
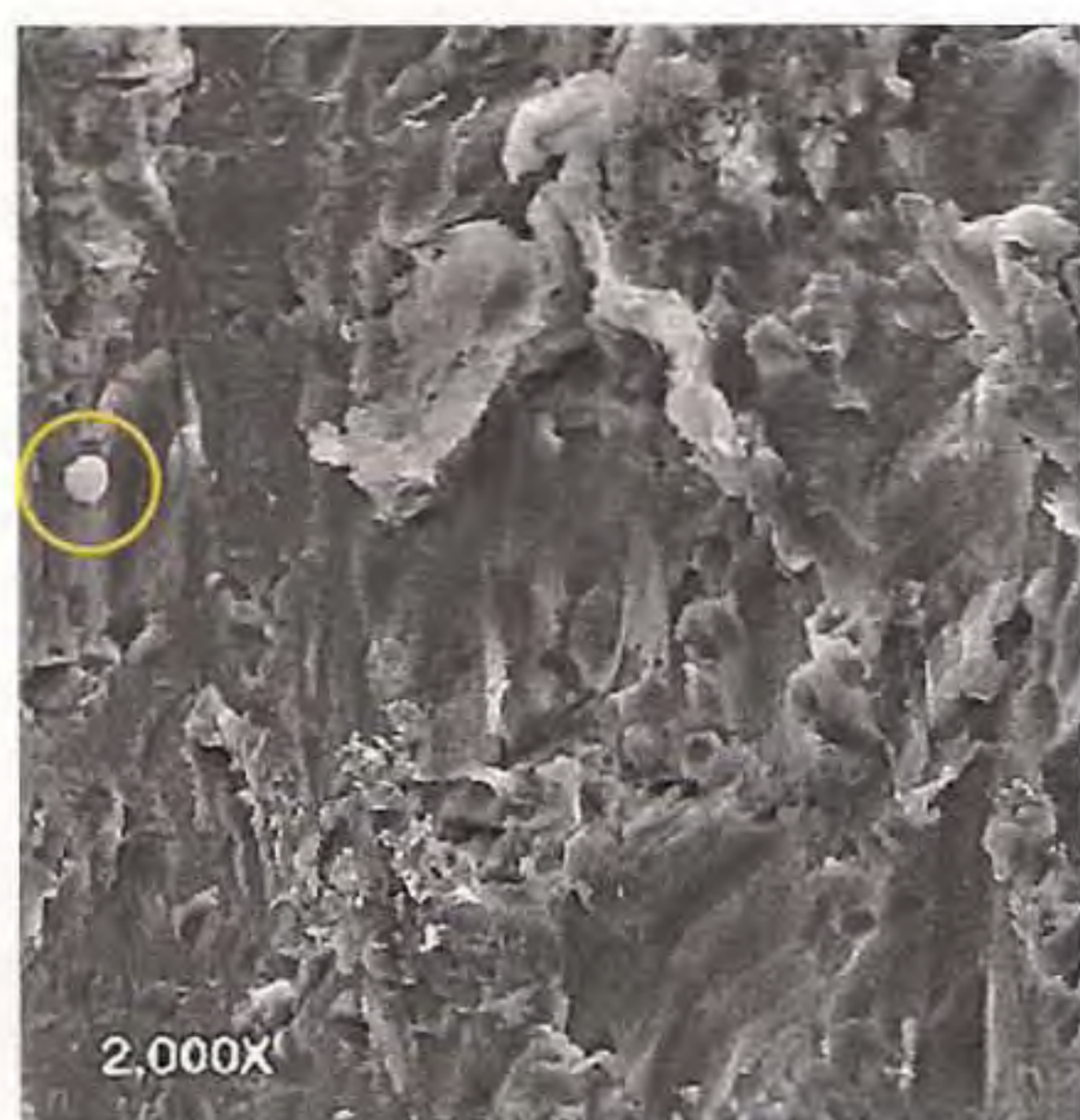


Fig 9-7 (far left) Microscopic examination of a surface treated with sandblasting. (circled area) Residual particles from the sandblasting are visible. (Original magnification $\times 2,000$.)

Fig 9-8 (left) Microscopic examination of an acid-treated surface (Osseotite). The irregularities are more uniform.

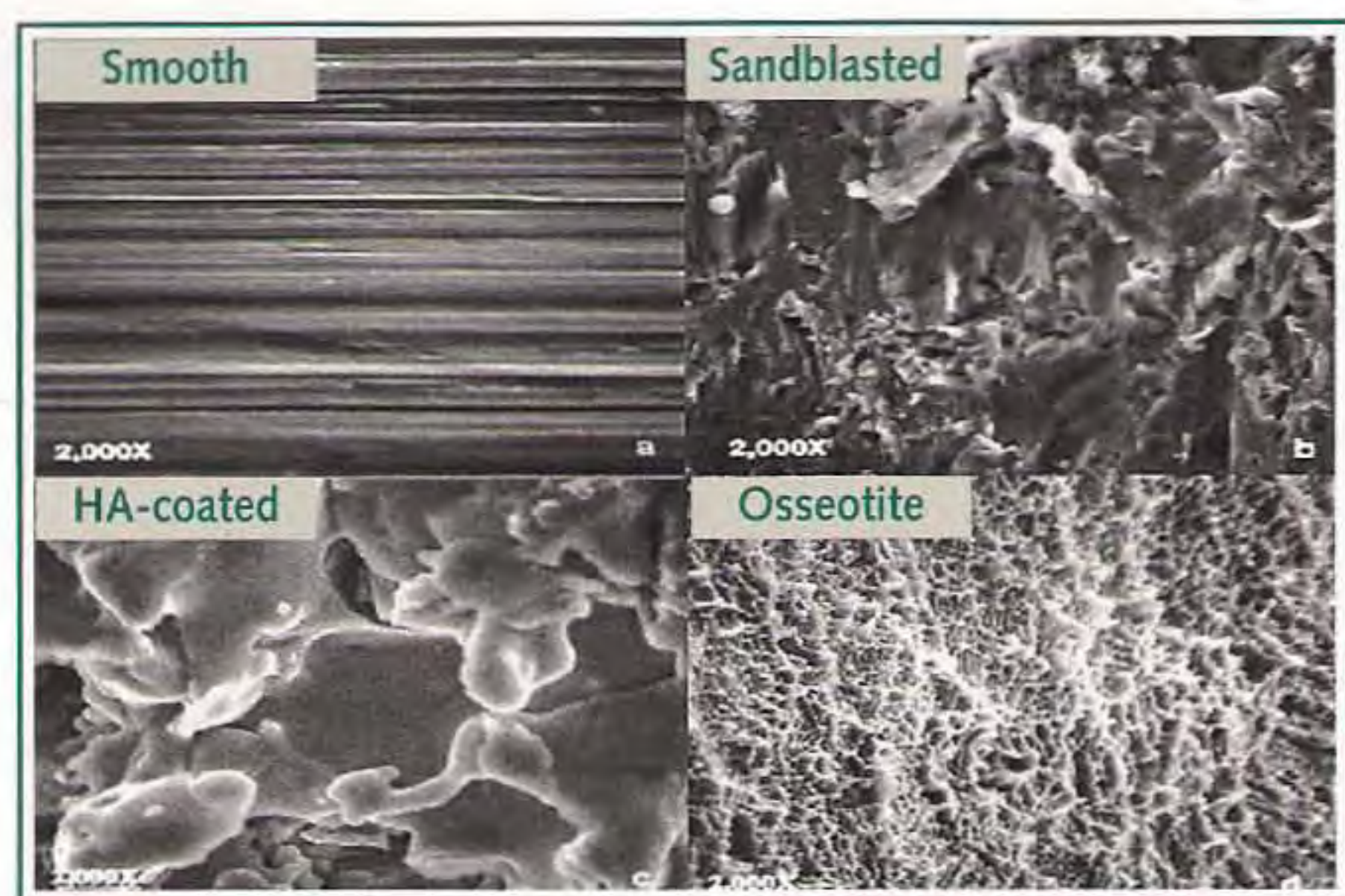


Fig 9-9 Microscopic comparison of implant surfaces. Note the differences between (upper left) a smooth surface, (upper right) a sandblasted surface, (lower left) an HA-coated surface, and (lower right) an acid-treated surface. (Original magnifications $\times 2,000$.)

Sandblasting is carried out by hitting the implant surface with aluminum oxide or titanium oxide particles, which create irregular dimples or depressions. The level of roughness depends on the diameter of the particles used, the duration of sandblasting, the pressure used, and the distance of the source from the surface of the implant. The average level of roughness obtained varies from 1.16 to 2.20 μm .²⁴ Some authors have shown that sandblasting causes a 15% reduction in the tensile resistance of the implant.²⁵ Furthermore, the surface of the implant can contain impurities, artifacts of the sandblasting process (Fig 9-7).

Etching is a method in which the surface of the implant is treated with an acidic solution. The variables of this method are the concentration and type of acid, the period of contact, and the temperature. In particular, the process of thermic etching in hydrochloric and sulfuric acid (Osseotite, 3i/BIOMET) allows

development of a microporous surface that is not excessively rough. The irregularities are more uniform (Fig 9-8), with a pore diameter of 1 to 3 μm , unlike HA and sandblasted surfaces, on which the irregularities are greater and distributed inconsistently (Fig 9-9).

Numerous studies have analyzed the reaction of bone to various types of implant surface. Wennerberg et al^{24,25} have shown that different treatments of surfaces bring about different biologic reactions: When minimal increases in the implant topography are present, only a minimal increase in the osseous implant contact occurs, while an excessive roughening brings about a decrease of this contact. Cordoli et al²⁶ have quoted the values of the removal torque and the histomorphometric results for four different types of implant surface (smooth, sandblasted, TPS, and Osseotite). The authors reported the values of bone-titanium contact on the tibia of a rabbit after 5 weeks: 72.4% for the Osseotite surface, 56.8% for TPS surfaces, 54.8% for sandblasted surfaces, and 48.6% for smooth surfaces. They also found that the values of removal torque for Osseotite implants were significantly higher compared to those for smooth, sandblasted, or TPS surfaces.

Lazzara et al¹⁹ carried out histologic research in humans in which they compared the percentage of bone-titanium contact between Osseotite and smooth surfaces in the same patient. To do this, titanium implants with two surfaces were produced, one side of which was treated and the other of which was smooth. The implants were positioned in the maxillary area characterized by the presence of type 4 bone. After 6 months of healing, a specimen was taken together with surrounding bone. The histologic examination revealed that, at 6 months of healing and in the absence of loading, the average bone-titanium contact was significantly greater with the rough surface than with the smooth surface (72.9% versus 33.9%). The results of this study indicate that, in bone that is of poor quality, the bone-titanium surface contact is greater if the implant

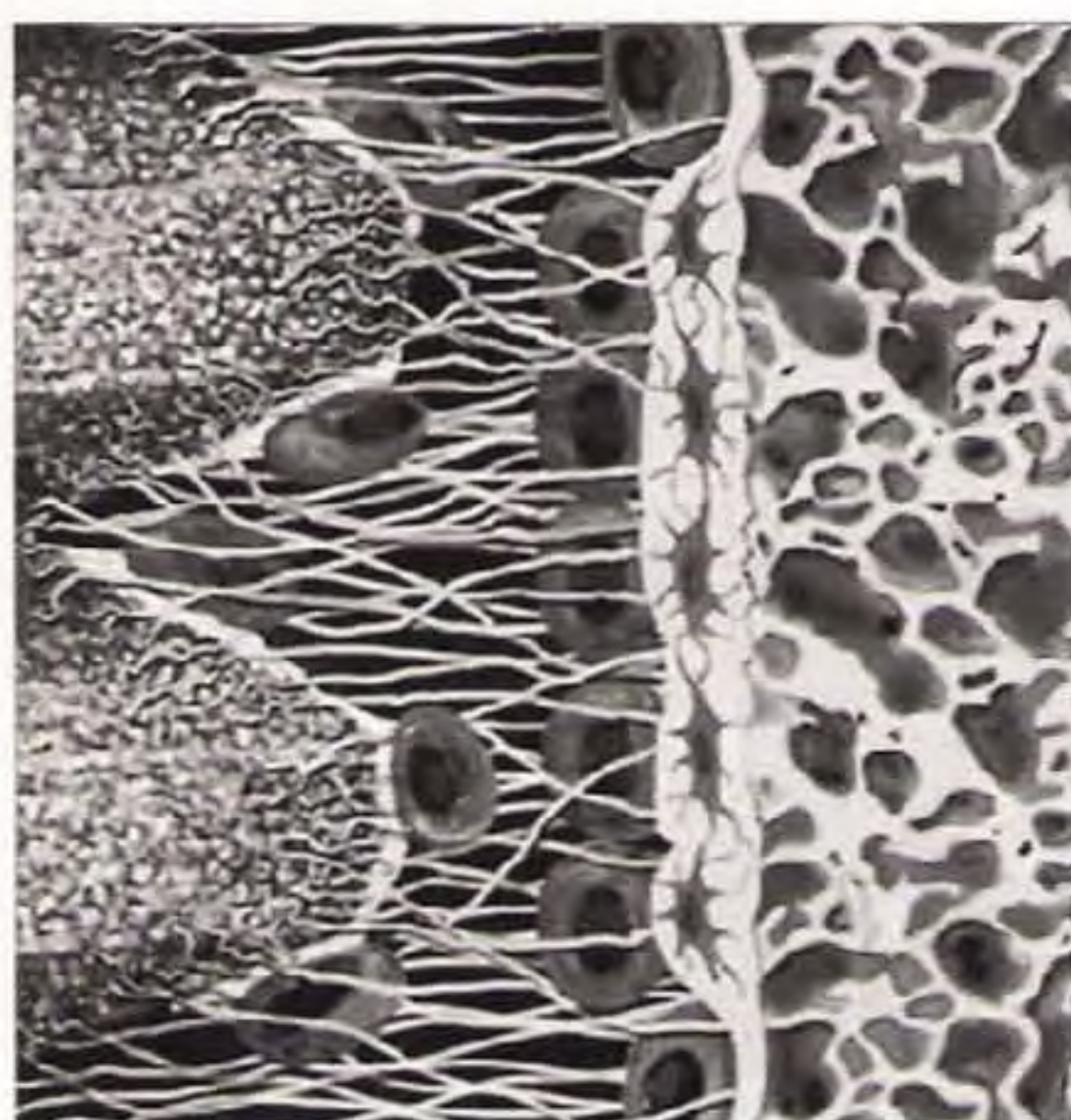


Fig 9-10 Bone-titanium interface with a fibrin network during contact osteogenesis.

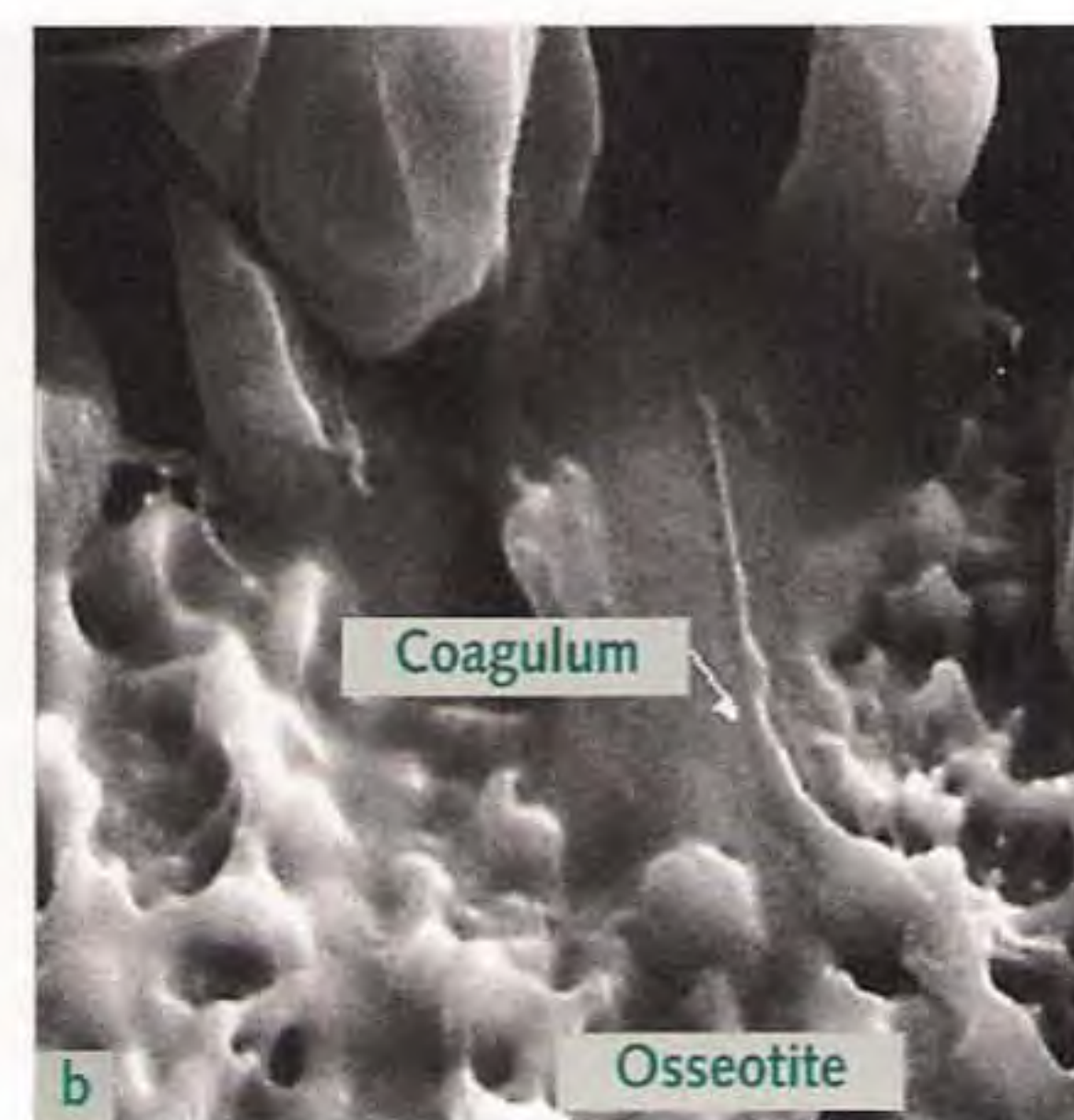
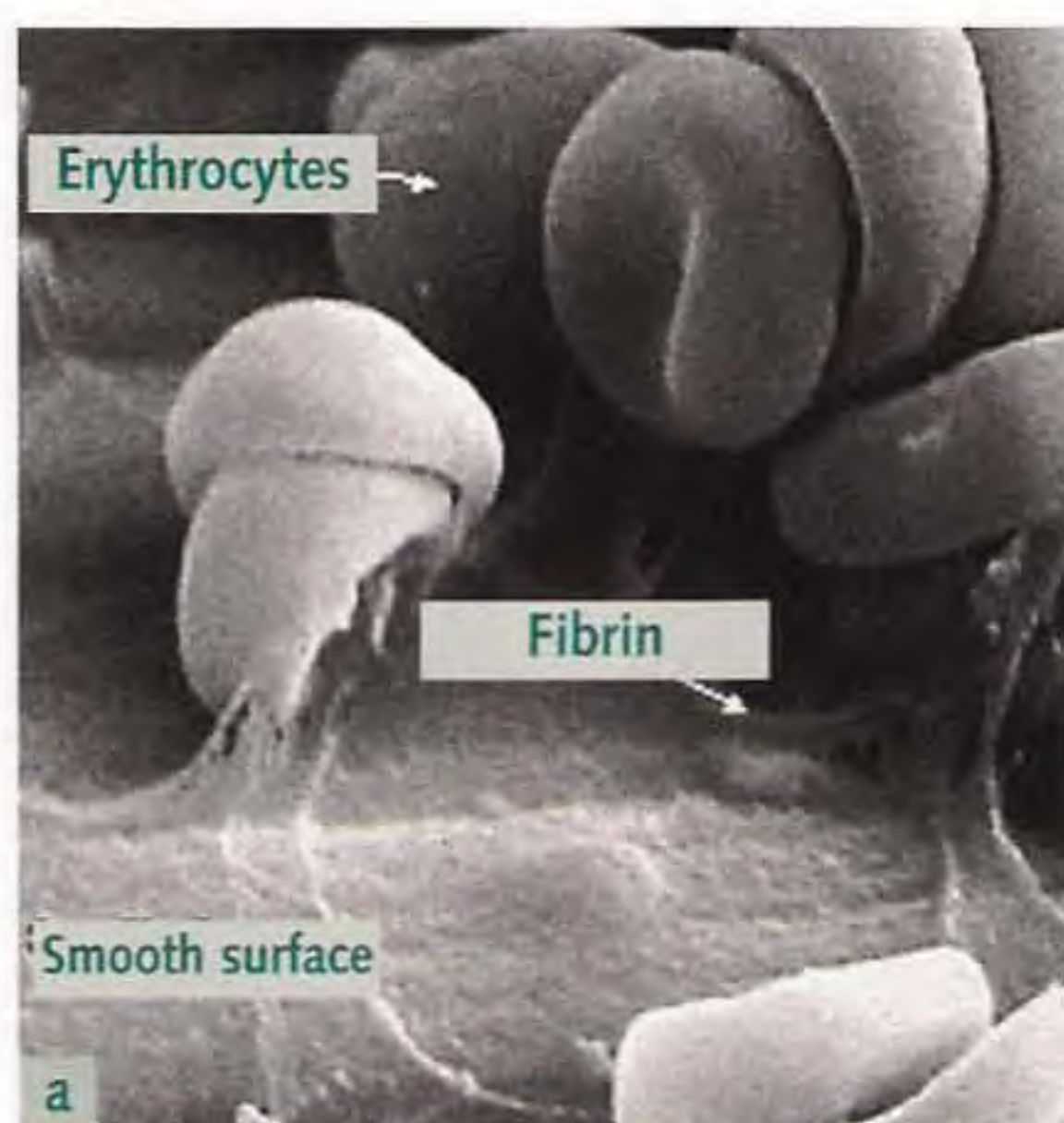


Fig 9-11 Microscopic examination of osteoprogenitor cells in contact with implant surfaces. (a) Smooth implant surface. (b) Rough implant surface. Due to its greater wettability, the rough surface retains the fibrin clot. (Figures courtesy of Biomechanics.)

surface is treated, suggesting the possibility of a quicker healing process and greater reliability (see Table 9-1).

Surfaces defined as porous were the last to have been described in literature.²⁷ The surface of the implant is treated with an electrochemical method and allows the following characteristics to be obtained:

- An increase in the coronapical thickness of the titanium oxide layer
- A coronapical increase in the surface roughness
- The presence, in the apical portion of the implant, of a surface structure with pores that are 1 to 2 μm in diameter

To understand how the surface topography of the implant can influence the bone biology, it is necessary to understand the healing mechanisms of the bone. During the positioning of the implant, blood fills the space between the surface of the implant and the bone. The coagulation phase brings about the formation of a fibrin network, which works as a biologic adhesive and provides a three-dimensional filling that is necessary for the migration of osteogenic cells (Fig 9-10). The coagulation of fibrin counters the three-dimensional contraction that can create a detachment from the surface of the implant and impede the contact of osteogenic cells with the implant surface. Experimental studies^{28,29} show that the adhesion of the fibrin clot to the implant surface varies in relation to the topography of the surface of the implant itself. In the presence of smooth surfaces, a detachment of the clot from the implant surface takes place, and the osseointegration comes about due to a process defined as *distance osteogenesis*: The empty space that exists between the implant and bone is filled with peripheral apposition, and the implant is progressively surrounded by new

bone. The implant surfaces remain separated from the new bone by the interposition of connective tissue until the process of osteogenesis is completed. This process requires a long time and an absence of implant loading.

Contact osteogenesis develops, on the other hand, in the presence of a treated surface: These surfaces, because of their greater wettability, retain the fibrin clot. This, in turn, acts as a precursor and activator of the platelets, which, in addition to forming the clot, also release growth factors that are indispensable to the first phases of bone and tissue healing. The osteoprogenitor cells remain in contact with the surface of titanium and deposit the bone matrix directly on the implant²⁹ (Fig 9-11).

This theory, as elaborated by Davies²⁸ in 1998, can, in part, explain the histologic and clinical findings of greater bone-titanium contact and shorter healing time in the presence of osteoconductive surfaces. Furthermore, rough surfaces are particularly indicated in the presence of risk factors, for example, poor bone quality or short implants.³⁰

These data highlight the importance of how the surface topography of the implant influences the quality and extent of the contact between bone and titanium; however, the osseointegration is not an episodic process but rather a continuous and dynamic process that accompanies the whole life of the implant and is influenced by many factors (among which is biomechanics).

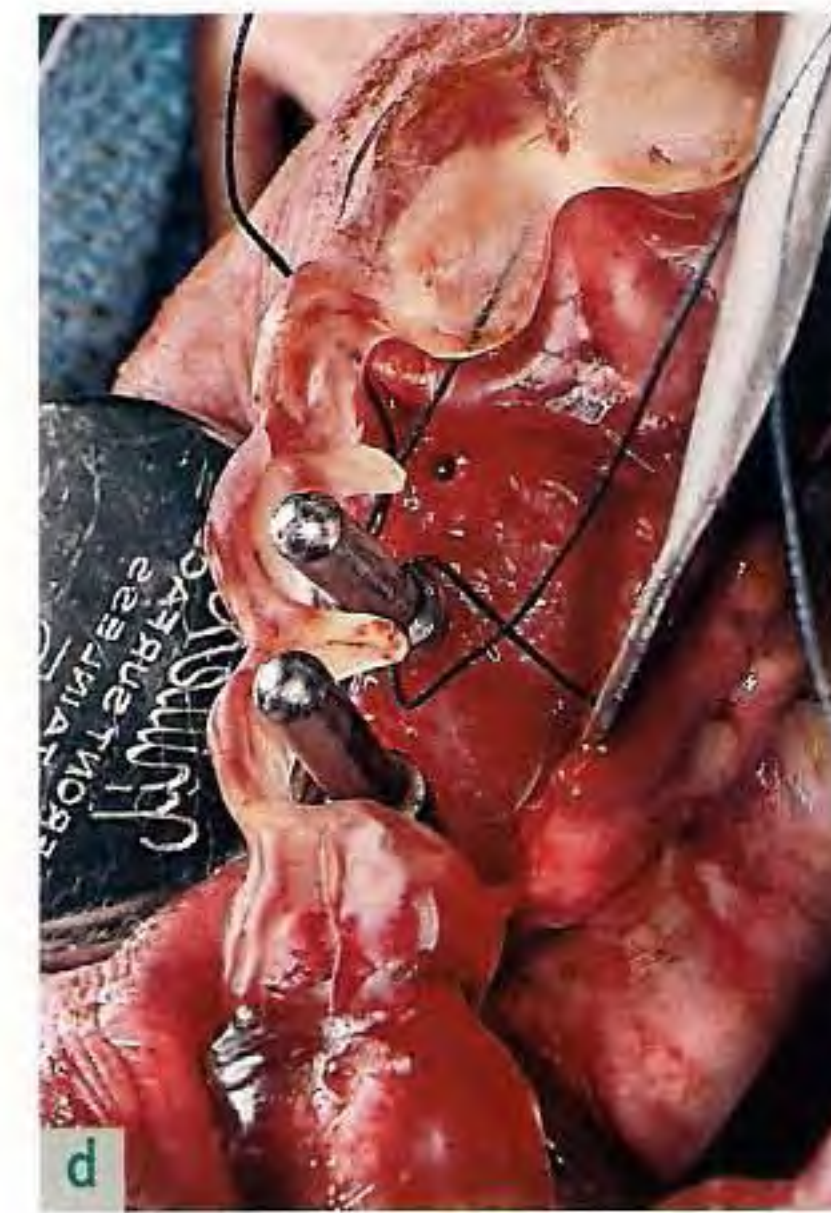
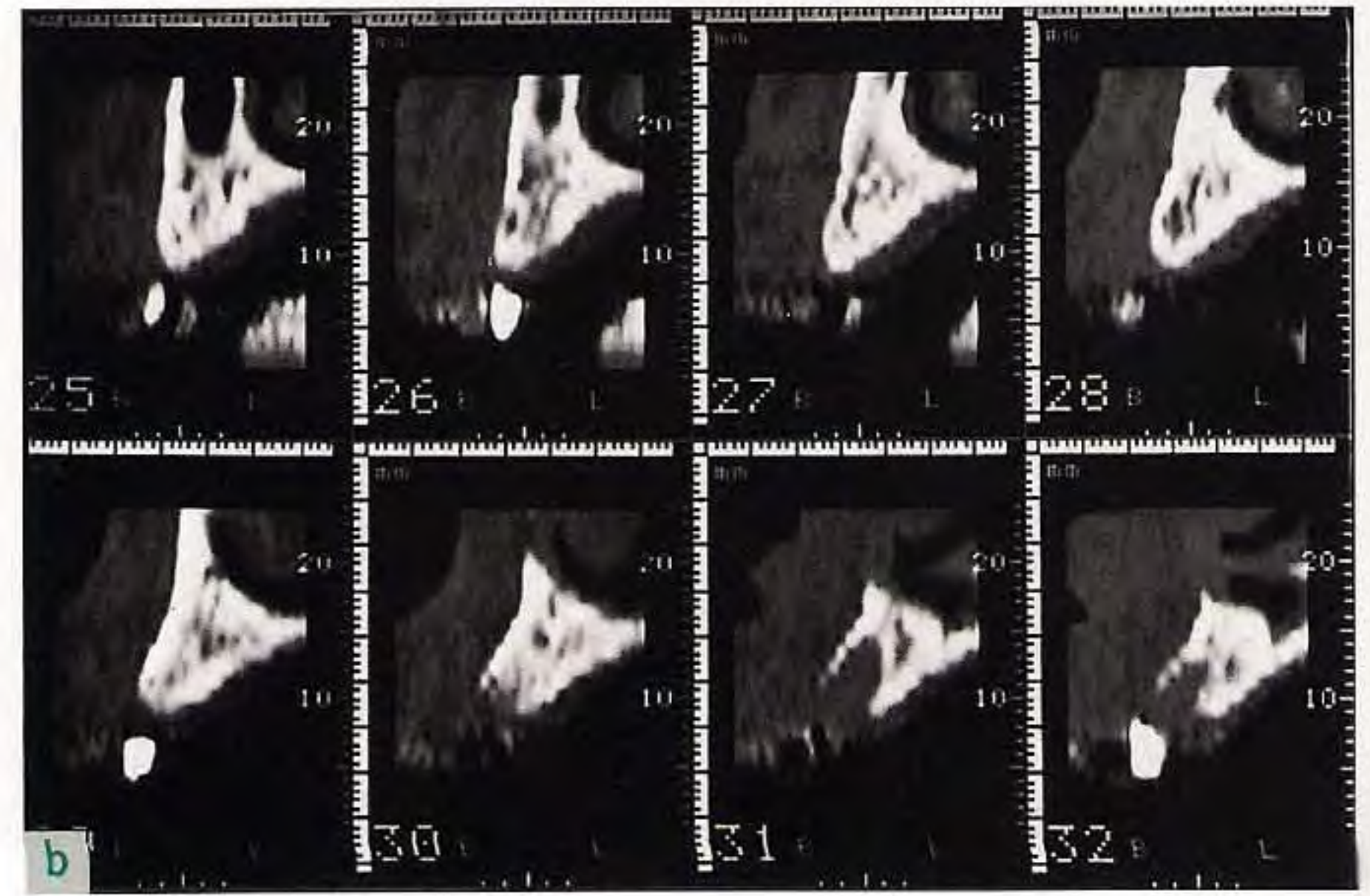


Fig 9-12 Preoperative procedure. (a) Radiographic mask or template (prepared with gutta-percha inserts); (b) CT scans; note the radiopaque markers in sections 26, 29, and 32; (c) modification of the radiographic template to a surgical template; (d) intraoperative use of the surgical template.

Implant-Prosthetic Treatment Planning

The clinical success of implant-prosthetic therapy depends on correct planning of the treatment, careful evaluation of the receiving osseous site, the choice of the most appropriate surgery, and correct design of the prosthesis. The detailed collection of case history data, careful clinical and radiographic examinations, and the scrupulous search for risk factors allow the clinician to reach a preliminary diagnosis of the possibility of undertaking implant treatment.

To realize a functionally and esthetically viable restoration, it is essential that planning of the prosthetic design precede surgery (prosthetically guided implantology). The fabrication of casts that are mounted in an articulator and a diagnostic waxup of the teeth to be replaced indicate the ideal positioning of the implants. As the basis of such planning, it is necessary to carry out simple radiographic investigations, such as panoramic radi-

ography, to verify the practicality of the implant treatment plan. If doubts exist concerning the location of vital anatomic structures that can be compromised by the insertion of implants, it is possible to make use of three-dimensional radiographic investigations,³¹⁻³⁴ such as traditional or computerized tomography (CT), which should be carried out with the aid of appropriate templates obtained from the diagnostic waxup³⁵⁻³⁸ (Fig 9-12). Images obtained in this way, together with clinical intraoral reevaluation of the surgical site, allow the clinician to corroborate the therapeutic plan, defining the position and the orientation of the implants, as well as their diameter and their length.

Once the collection of data has been completed and the prosthetic planning is accomplished, it is necessary to evaluate the particular characteristics of the receiving osseous site, determined by the modality of bone resorption, to adopt the most appropriate surgical technique.



Fig 9-13 Fixed mandibular complete-arch prosthesis. Ceramic is the best occlusal material for implant-supported restorations.

Biomechanical Aspects

In the last 10 years, research is believed to have found the basic elements for long-term success of implant-prosthetic therapy in biomechanical requirements¹⁷ and in the need to orient surgery accordingly. Occlusal overloading has been identified as one of the principal causes of delayed failure (loss of osseointegration) or fracture of the mechanical components.³⁹ In 2000, Taylor et al⁴⁰ highlighted the fact that the literature of the 1990s had been enriched by centralized studies on the necessity of protecting implants from occlusal overloading through the choice of occlusal surface, the disposition and number of implants, the mechanical properties, and the fit of the prosthetic components. Today, vast clinical experience and new research require a reevaluation of these criteria.

Masticatory and occlusal surfaces

At the beginning of the 1990s, the adoption of resin masticatory surfaces^{41,42} was believed to protect the implants from occlusal overloading. Many authors^{43–45} have studied the power of impact absorption of the materials that are most commonly used to coat occlusal surfaces, in the conviction that more resilient materials reduce the load transmitted to the implants by acting as stress absorbers. Others have suggested that the use of resin surfaces in the initial phases of restoration, with the aim of allowing “a progressive adaptation to the load” is not well substantiated.⁴⁶ Nevertheless, today, the lack of scientific support based on experience *in vivo*⁴⁷ and the esthetic needs of the population have made ceramic the occlusal material of choice⁴⁸ (Fig 9-13). The validity of this choice, which has been shown to be in contrast with research results *in vitro*, is



Fig 9-14 For extensive implant-supported prostheses, the Michigan splint is useful to prevent damage caused by parafunctional activity in patients with bruxism.

now supported by the success of these restorations. As far as occlusal morphology is concerned, the information present in the literature is more anecdotal than scientific. According to prevailing opinion, the angulation of the cusps must be reduced to direct the resultant occlusal forces within the diameter of the implant.⁴⁹ Even the occlusal design should contribute to the prevention of stress on the implants, for which designs that allow a more homogenous distribution of occlusal load are preferred, such as group guidance in treatment of partial edentulism and balanced occlusion in the case of complete edentulism.⁴⁹ Furthermore, it is good practice to finalize extensive implant-prosthetic restorations with a Michigan splint, to prevent damage caused by parafunctional activity in patients with bruxism (Fig 9-14; also see chapter 4).

Axial and transverse loading

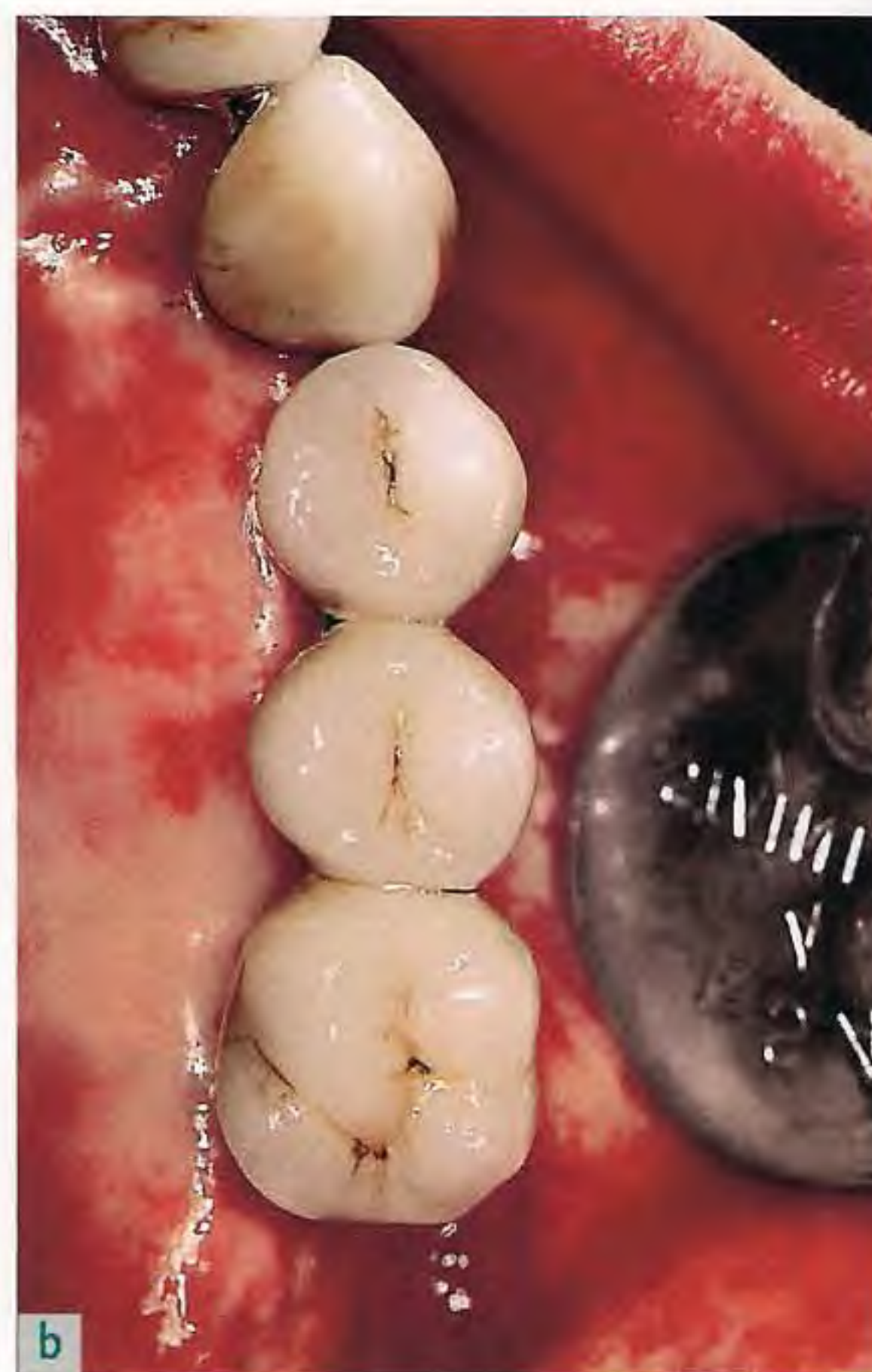
The need to insert implants in a way that avoids nonaxial and cantilever loading has been emphasized for years.¹⁷ The tripod rule—which dictates that implants not be placed in a line (Fig 9-15)—was adopted because of the need to counteract the masticatory load with a prosthetic configuration that would reduce the transverse components to a minimum. The idea of reducing the distal extensions and containing the length to less than 1.0 cm for the complete maxillary arch and 1.5 to 2.0 cm for the complete mandibular arch was suggested based on the same principle. The necessity of positioning the implants so that the masticatory load is transmitted along the main axis of the abutment clashes, however, with the complexity of the clinical and anatomic situations that affect the insertion axis of the implant:



Fig 9-15 Tripod placement of implants. The implants are not aligned.



Fig 9-16 Restoration of a completely edentulous area. (a) Three implants support (b) a fixed prosthesis. There is not always space on the edentulous crest to place three implants according to the tripod rule.



- It is not always possible to place three implants, and the width of the bone crest is not always sufficient to change the alignment (Fig 9-16).
- The first protocol for prosthetic restoration of implants, the fixed complete-arch prosthesis, was born as a fixed implant-supported prosthesis with distal extensions that were not limited in length; to date, no study has been able to identify distal extensions in a fixed complete-arch denture as a risk factor for failure (Fig 9-17).
- The single tooth replacement, despite representing one of the potentially most critical situations in which transverse and rotational loads prevail on the implant, today represents one of the most valid options for restoration of intercalated edentulous spaces in both posterior and anterior segments.

Even if there is no scientific evidence of the damage potential of transverse application of the masticatory load on implants, clinical practice argues for an implant position that allows correct emergence, so that the main axis of the implant is as perpendicular as possible to the load and the clinical crown and the axis of the implant are aligned. Respect for these criteria obliges the clinician to place an implant with the same orientation as the tooth that it replaces. This technique is known as prosthetically guided implantology.

Adaptation of the pontic to the implant

In the last decade, the attainment of a perfect adaptation between the pontic and the implant has been considered an essential prerequisite for the success of fixed implant restorations.⁵⁰⁻⁵² In the prosthesis supported by natural teeth, the periodontal ligament confers a certain mobility to the abutments and therefore allows adaptation to a prosthetic structure that is not perfectly passive. With restoration on implants, the attachment of an imprecise pontic, to which the integrated implant of the bone cannot adapt itself, causes a constant pre-load. This, added to the masticatory load, could result in excessive concentrations of stress in the surrounding bone, causing loss of integration. Thousands of fixed partial dentures have been sacrificed on the altar of the passive fit, the perfect coupling between superstructure and implants. Even this literature represents far from indisputable scientific evidence and, after just a few years, is today in clear contrast with the growing experience of clinical practice. Jemt and Book,⁵³ in a study carried out in 1996, showed that, after 5 years, an imperfect adaptation of a screw-retained prosthesis to an implant (termed *misfit* by the authors) resulted in clinically acceptable loss of marginal bone and that the bone loss was not significantly correlated with the degree of the misfit. Research still has not investigated the real biologic tolerance of the surrounding bone in



Fig 9-17 Panoramic radiograph of a fixed mandibular complete-arch prosthesis; note the distal extensions.

relation to the danger generated by the lack of passive adaptation of a prosthesis. What is certain is that a lack of adaptation of the pontic predisposes the prosthetic components to fracture or unscrewing. From this point of view, research on good adaptation of the prosthesis to the abutment remains a valid clinical criterion for study.

Mechanical properties of the implant

Placement of implants with a wide diameter is justified by the need for mechanical components that are more resistant, especially in the posterior segments, and in harmony with the diameter of the clinical crown (Fig 9-18). A specific protocol was not created, however, before the adoption of smooth implants with a wide diameter. Eckert et al⁵⁴ have reported that, at the moment of marketing and large-scale use of smooth implants with a wide diameter, there are no research data proving their effectiveness or revealing a reliable percentage of survival. Eckert et al⁵⁴ concluded that these implants are, in fact, associated with a high percentage of failure, although they were not able to correlate this information with any specific risk factors (eg, smoking, bruxism). With the adoption of treated surfaces, even wide-diameter implants present a success rate similar to that of implants with a standard diameter.

Connection between teeth and implants

The means of connecting natural teeth to implants has been discussed at length. Many authors have shown, on the basis of in vitro and in vivo studies, that the presence of the periodontal ligament gives the natural abutment a mobility that, in the



Fig 9-18 Intraoral radiograph of a large-diameter implant. In fixed restoration of posterior segments, these implants are the preferred choice, because they have better mechanical resistance and improve the emergence profile of the clinical crown.

case of rigid connection with an implant, determines the transfer of the majority of the occlusal load to the implant and the bone to which the implant is rigidly anchored. A logical deduction, but one without scientific evidence, has induced the profession to consider this configuration to be potentially damaging for the health of the implant.⁵⁵

At the end of a 10-year follow-up study using the split-mouth design, in which a fixed partial denture was placed on two implants on one side and a fixed partial denture was placed on a tooth and an implant on the other side in 23 patients, Gunne et al⁵⁶ did not find any difference in the success rate of the two prosthetic configurations or any difference in terms of marginal bone loss or incidence of mechanical complications. The authors recommended tooth-implant connection in the restoration of the posterior segments. Another recent comparative study between prostheses with implant support and those with mixed support did not show differences in the longevity of the implants but revealed a greater number of prosthetic complications with the mixed-support design.^{57,58}

A complication that is frequently associated with the fixed partial denture with mixed support and nonrigid connections is the progressive intrusion of the natural abutment⁵⁹⁻⁶¹ (Fig 9-19). Even if there are different theories in the literature to explain this problem, from atrophy arising from lack of use to the entrapment of solid food fragments, at the moment there is no scientific evidence that can clarify the phenomenon.⁶²⁻⁶⁴

The current design that is most reliable incorporates a rigid prosthetic connection between implant and natural teeth. Such a solution has been proposed by different authors on the basis of in vitro studies, in which it is hypothesized that the flexibility of the mechanical components of the implant system are suffi-

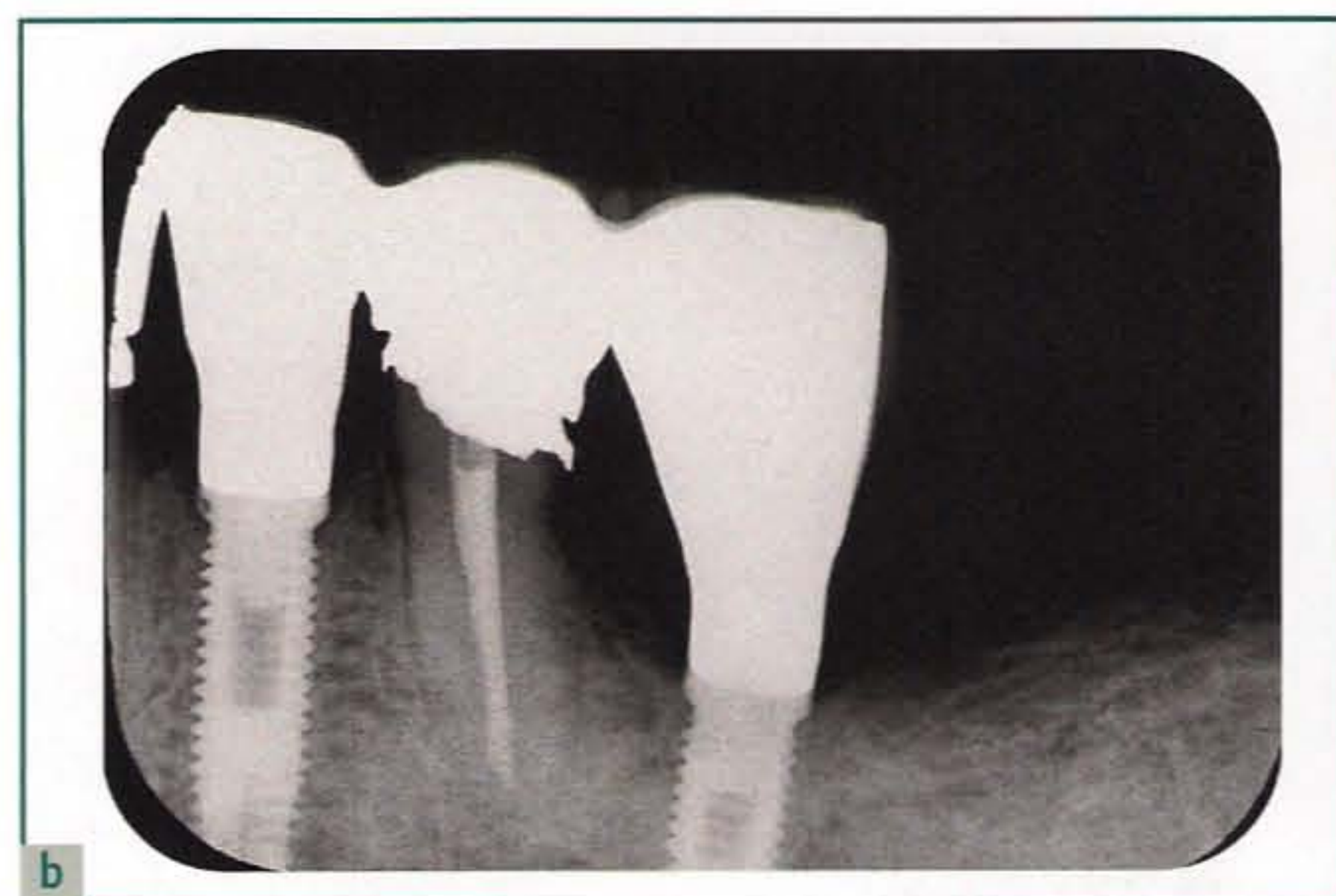


Fig 9-19 Intrusion of a natural abutment in a telescopic prosthesis with mixed support. Radiographs taken (a) at the placement of the prosthesis and (b) after 6 months. (Courtesy of Dr G. Cho, Los Angeles.)



Fig 9-20 Prosthesis that links two natural teeth and a distal implant by means of a rigid screw attachment.

cient to compensate for the periodontal ligament,^{65,66} and supported by clinical data.^{59,67-69} The disadvantage of a rigid design with soldered connectors is the impossibility of reintervention. To prevent this inconvenience, the use of screw attachments, also in the connection with the natural tooth, has been proposed⁷⁰ (Fig 9-20).

The Turin school,⁷¹ in research carried out in vitro with the aid of a mathematical model, has shown that, by virtue of the viscoelastic properties of the periodontal ligaments, the distribution of the stress on the bone surrounding the connection between tooth and implant seems to be dependent more on the duration of the load rather than on its intensity. When a tooth is subject to a transitory load, independent of its intensity, the brief application of the load is not sufficient to intrude the tooth. In this way, the tooth reacts similarly to the implant. If the tooth and implant are rigidly connected, therefore, the

load is distributed among both in a homogenous way. The natural abutment and the implant show differences in behavior, on the other hand, when a load is applied for a long period of time, bringing about an intrusion of the tooth in the socket.

In view of the success shown in vivo of restorations that involve natural teeth linked rigidly to implants, this prosthetic configuration is becoming a valid option in today's practice (Fig 9-21). Nevertheless, cases in which it is actually necessary to link natural teeth and implants are rare. For this reason, despite the fact that the taboo against connecting teeth and implants in healthy periodontium has today been refuted, clinical experience advises the separate restoration of natural teeth and implants.

Prosthetic connection

Depending on the type of connection of the superstructure of the implant, the fixed partial prosthesis can be screwed or cemented. The screw-retained prosthesis has the primary advantage of scientific validation, given the numerous clinical studies.⁷²⁻⁷⁷ The connection of the crown to the abutment with screws allows, if necessary, the easy removal of the construction, in many cases avoiding the need to rebuild the prosthesis. This explains the higher success rate of implants restored with this type of prosthesis, shown in the studies cited in the previous sections. The drawbacks of the screw-retained prosthesis include reduced esthetic quality caused by the access holes for the screws and the complex prefabricated components needed (Fig 9-22).

The cemented prosthesis is without doubt the easiest to fabricate for the dental technician and has superior esthetic properties, because it does not need access holes in the occlusal surface. (Fig 9-23). Nevertheless, it is still not supported by ade-

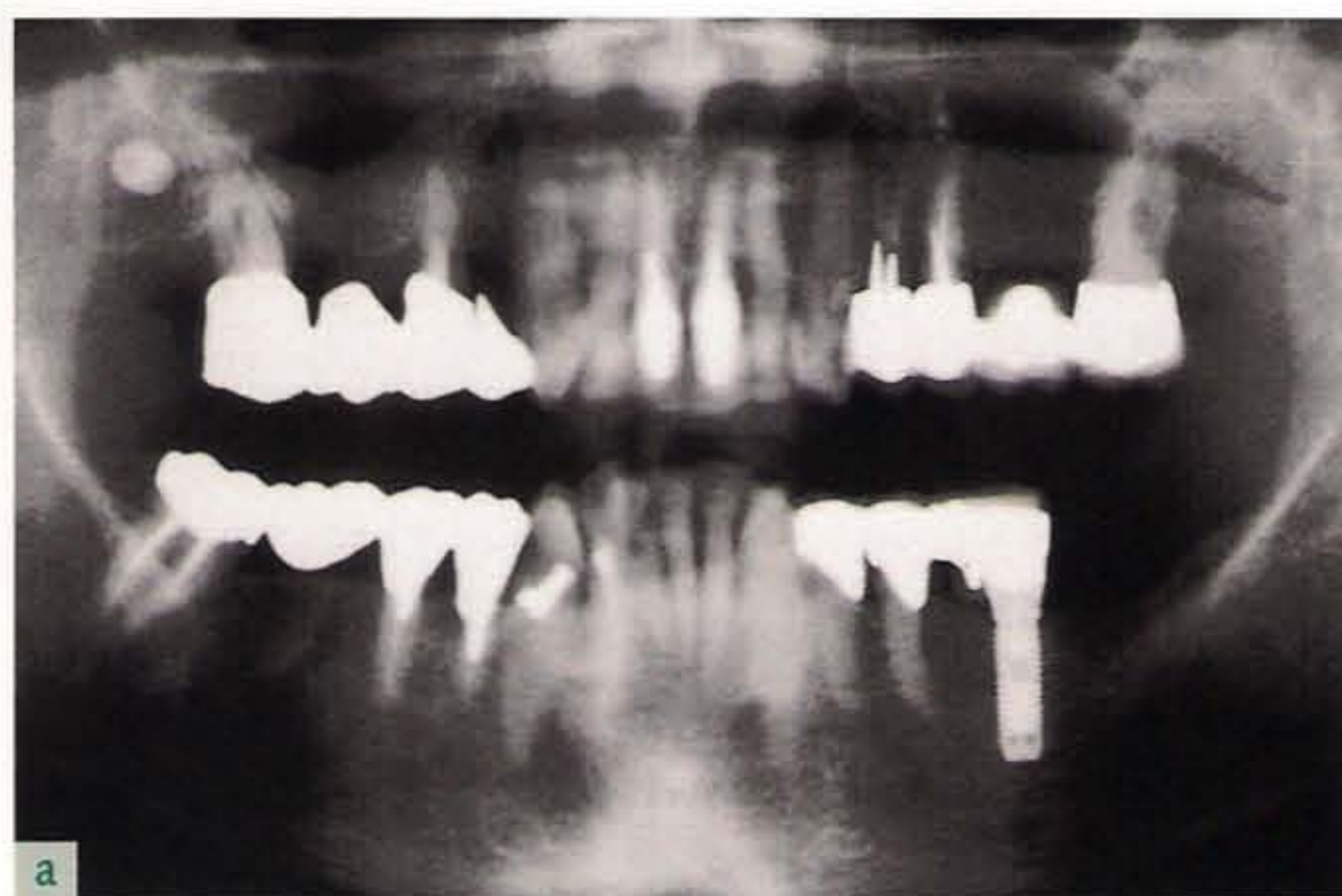


Fig 9-21 (a) Radiographic view and (b) clinical view of the restoration of a distal edentulous space by means of an implant rigidly connected to two natural abutments.



Fig 9-22 (a) Distal restoration with a metal-ceramic prosthesis supported by implants. (b) The presence of screw access holes, even if covered by resin composite, reduces the quality of the esthetic result.

quate long-term scientific research.⁷⁸ To allow for corrections in the case of cemented prosthesis, different authors advise the use of temporary cement.⁷⁹⁻⁸² This solution is limited, however, by the lack of documentation available on the type of cement that is most commonly indicated in different clinical situations and by the problems related to cementation.⁸³⁻⁸⁷

Among clinicians, the primary criterion for deciding between the two types of prosthetic technique is still based on personal preference.^{88,89} While waiting for definitive and confirmed guidelines based on scientific research, the Turin school prefers the screw-retained prosthesis, when possible, to the cemented one.



Fig 9-23 Fixed prosthesis cemented on implants. The esthetic result is better than a screw-retained prosthesis, because no access holes are needed for the screws.

Obstacles to Implant Placement: Resorption of the Alveolar Crests and Osseous Limitations

Total and partial implant-prosthesis restoration of completely edentulous patients requires a bone quantity sufficient for implant placement. After the extraction of teeth, the alveolar process loses its function and moves toward resorption. The severity and mode of resorption depend on the cortical thickness, the disease that has necessitated the extraction of teeth, the technique of extraction, the time elapsed since extraction, and, finally, the type of prosthesis worn by the patient.

The maxillary bone cortex is thinner buccally and palatally; for this reason, postextraction resorption takes place in the buccal-palatal directions. The maxilla therefore presents an osseous resorption of the centripetal type. In the mandible, the osseous resorption of the anterior region is centrifugal, with an osseous loss mainly in the lingual cortex. In the posterior segments, the resorption proceeds simultaneously in the two cortices and in a predominantly vertical direction.⁹⁰

The disease that brought about the extraction of the tooth influences the normal process of osseous remodeling. An infective etiology causing the loss of a tooth always involves a slower healing process and consequently greater resorption. The osseous resorption is, however, influenced by the extraction technique. As Michael and Barsoum⁹¹ affirmed, extraction that is realized with the smallest possible osteotomy and exposure of the periosteum is the best means for minimizing osseous resorption.

After the loss of the teeth, resorption is greatest in the first year (10 times more than that of the following years) and more accentuated in the anterior segments than in the posterior segments.⁹² In the following years, a small but constant decrease in the bone quantity takes place.

If the patient who is rehabilitated with a complete prosthesis does not have regular examinations of the occlusal contacts, the vertical dimensions, and the congruency of the denture base, an anterior rotation of the mandible occurs, which pushes the maxillary prosthesis in a ventral direction and the mandibular prosthesis in a dorsal direction. The altered distribution of the masticatory loads causes a concentration of functional forces on limited areas of the edentulous maxilla, especially in the anterior segments, with a consequent increase in osseous resorption. In this way, a vicious circle is initiated: reduction of the vertical dimensions, anterior rotation of the mandible, and concentration of masticatory forces on areas that are always reduced.

This process is further accelerated in patients who have complete maxillary prostheses and natural mandibular canines and

incisors, which exert an increased load on the complete maxillary prosthesis. The accelerated osseous resorption of the incisive bone accompanied by hypertrophy of the maxillary tuberosity has been defined by Kelly as *combined syndrome*.⁹³

Despite the identification of many factors that influence the physiopathology of the resorption of the residual alveolar crest, individual variations of this process have still not been completely clarified. Woelfel and collaborators⁹⁴ have identified 63 factors that can be correlated to postextraction osseous resorption, but they have not found any factors that can explain, by themselves, the individual variations of osseous resorption.

Classification of osseous availability

The concept of available bone in implantology is particularly important inasmuch as it defines the external architecture and the volume of the edentulous area. Classifications of the edentulous arches in terms of osseous availability have been proposed by various authors over the last 30 years. Those of Cawood and Howell⁹⁵ have been relatively well accepted. They were the first to analyze both jaws from this point of view. The first systemic classification was proposed by Zarb and Lekholm.⁹⁶ In this classification, the authors described five phases (A, B, C, D, and E) of resorption of the jaws without referring to variations of form and without indications for the different methods of implant restoration (Fig 9-24).

Only Misch and Judy⁹⁷ have published a classification of diverse osseous morphologies, subdividing the available bone into four groups (A, B, C, and D): Each of these is analyzed according to its own particular characteristics, height, and thickness, and in this way the best surgical and prosthetic treatment plan can be determined for edentulous and partially edentulous patients.⁹⁸

- Class A: abundant bone
- Class B: minimum sufficient bone
- Class C: reduced bone
- Class D: insufficient bone

In the literature, there is no information about the direct correlation between osseous quantity and implant success. The influence of osseous quantity on the long-term results can be evaluated indirectly by correlating implant success to the length of the implants. It is evident that the implants with a greater percentage of success are those that are 10 mm or longer (without great variations in the success rate for implants greater than 10 mm). For implants shorter than 10 mm, the failure rate increases as the length of the implant decreases.^{12,72}

The osseous quality is determined by the quantitative relationship between cortical and spongy bone. The cortical bone is the dense and more mineralized part of the bone, while the

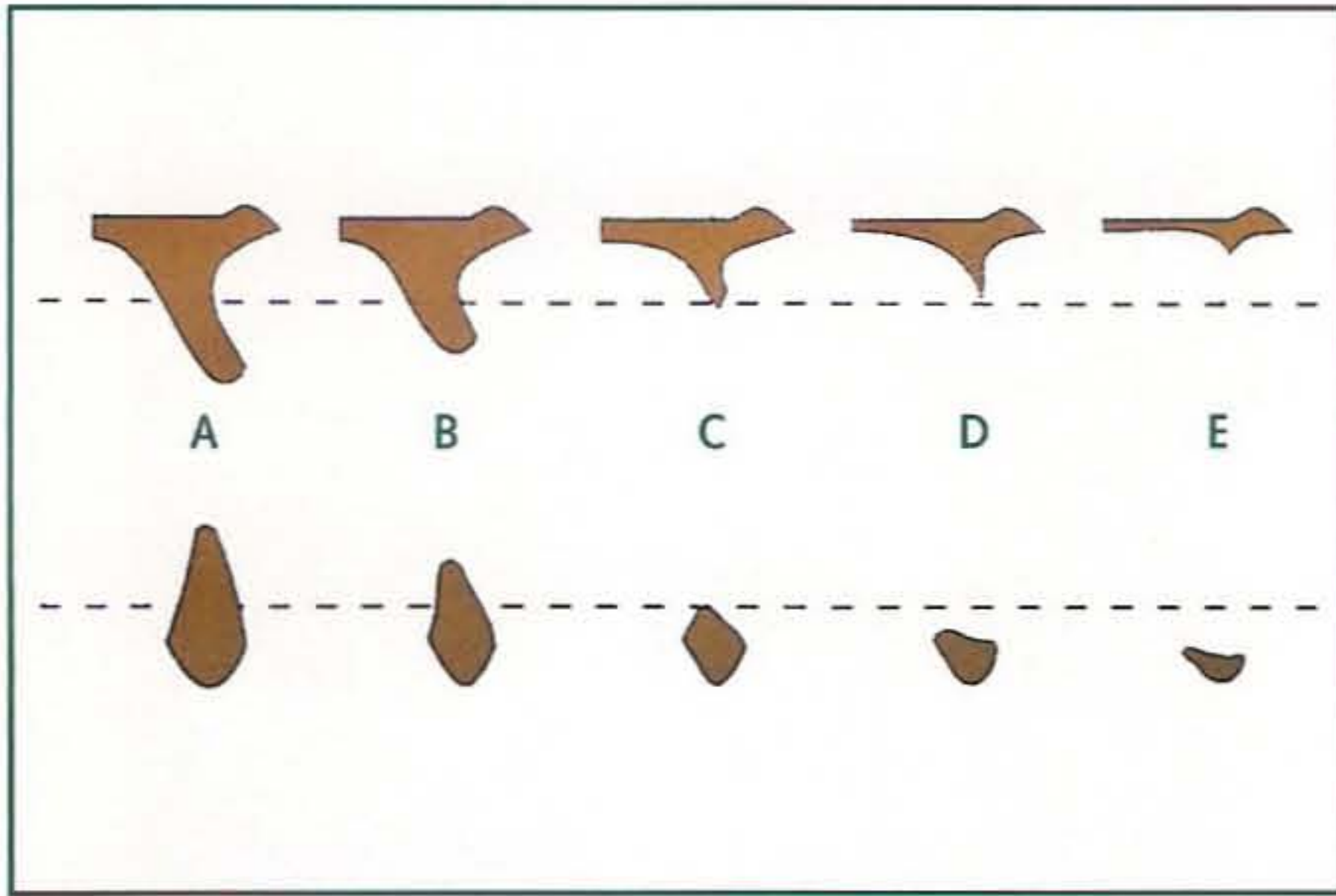


Fig 9-24 Classification of bone quantity according to Lekholm and Zarb.⁹⁶

spongy bone is made up of trabecular tissue that is only slightly mineralized. The quality of the bone represents a prognostic parameter that is important in implant-prosthetic treatment. Different studies^{96,99} have associated a greater percentage of failure with poor bone quality, characterized not only by lack of density but also by excessive density. For this reason, it is important to carefully evaluate the osseous quality, both preoperatively as well as during the surgical phase, to adopt the most appropriate implant technique.

In 1985, Zarb and Lekholm⁹⁶ introduced a classification of the osseous quality of the maxilla in patients who are completely edentulous, based on preoperative radiographic evaluation and on the subjective perception of osseous resistance to cutting during preparation of the implant site.

Four categories have been proposed (Fig 9-25):

- Type 1 bone: compact and homogenous bone that is almost entirely cortical
- Type 2 bone: compact cortical bone with dense trabecular areas
- Type 3 bone: thin cortical bone with dense trabecular areas
- Type 4 bone: thin cortical bone with less dense trabecular areas

In 1987, Misch and Judy⁹⁷ extended this classification to the whole craniofacial region, basing it on the macroscopic characteristics of the cortical and the spongy bone. The osseous density is divided into 5 classes (from D1 to D5, in order of decreasing density). D1 bone is never found in the maxilla, while it is always present in the mandible, in the symphysis, in cases of heightened osseous atrophy. Density D2 is observed more frequently in the mandible and in the maxilla: It is possible to compare the partially edentulous regions to the bone around incisors, canines, or premolars. Bone of D3 density is

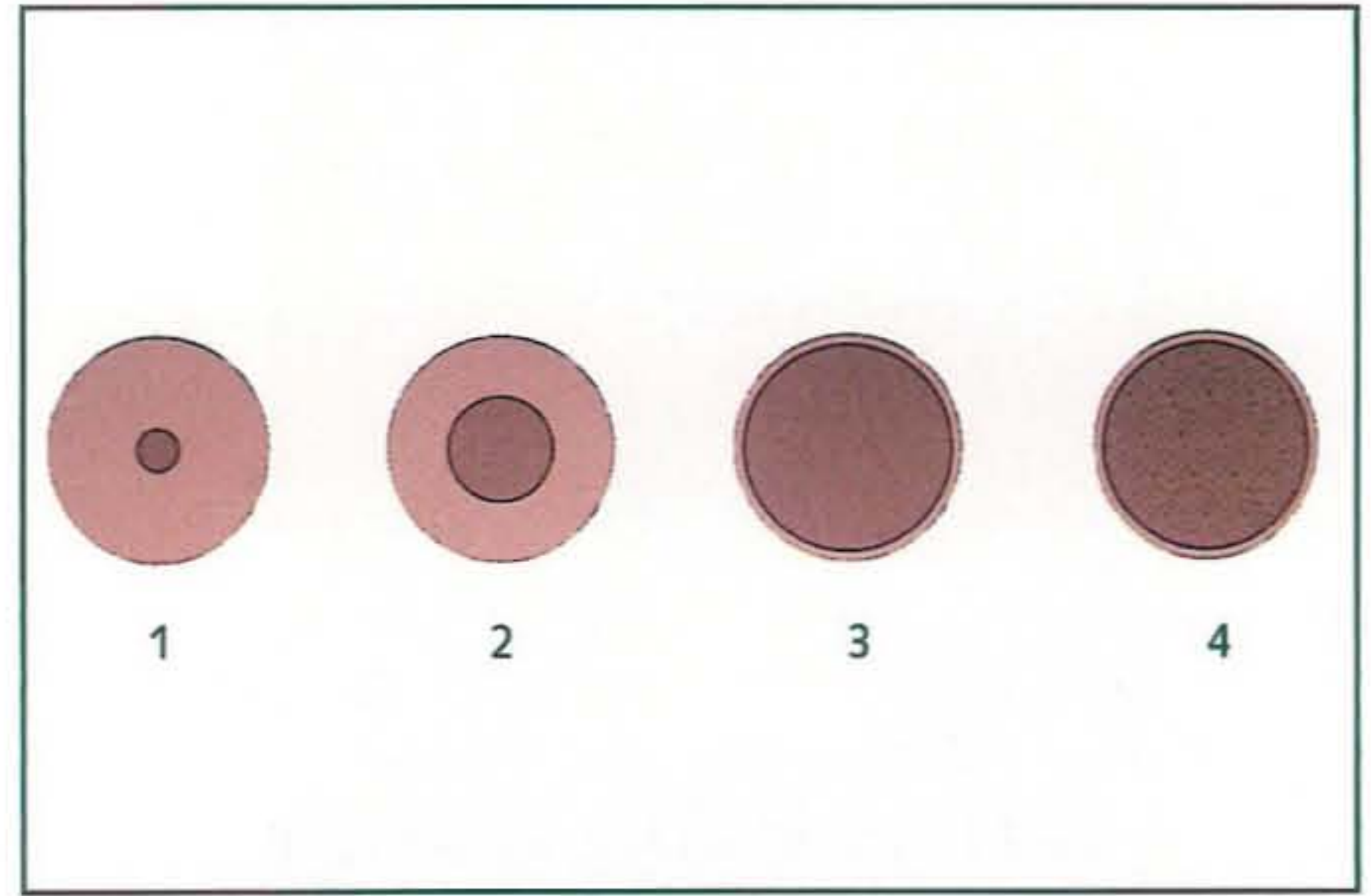


Fig 9-25 Classification of bone quality according to Lekholm and Zarb.⁹⁶

very common in the maxilla. D4 bone is found in the distal areas of the maxilla in 40% of patients and anteriorly in 10% of patients. In the mandible, D4 bone may be found distally in crests with otherwise acceptable volume. The designation D5, in this classification, signifies immature bone.

Trisi and Rao¹⁰⁰ have correlated different clinically assigned classes of osseous density, making their evaluation at the moment of implant insertion, with the percentage of trabecular bone measured histomorphologically from osseous biopsies carried out during implant surgery. They showed that the subjective perception of the operator is able to distinguish, according to the Misch and Judy classification,⁹⁷ D1 bone from the D4 bone in a statistically significant manner. Intermediate classifications of bone quality cannot be discriminated.

Osseous quality is an important factor for the long-term success of the implant treatment. A heightened osseous density (D1) represents a risk factor because of the ease with which the bone overheats during preparation of the site. In the D4 bone, the greatest difficulty consists of acquiring primary stability of the implant, obtainable only through modification of the standard surgical protocol.

Guidelines for Maxillary Implant Surgery

The possibility of positioning implants must be evaluated on the basis of the structural and morphologic characteristics of the edentulous regions.^{101,102} The edentulous maxilla can be subdivided into three regions: one each on the right and on the left, distal to the second premolar where the sinus limits the height of the bone available, and an anterior region of the inci-

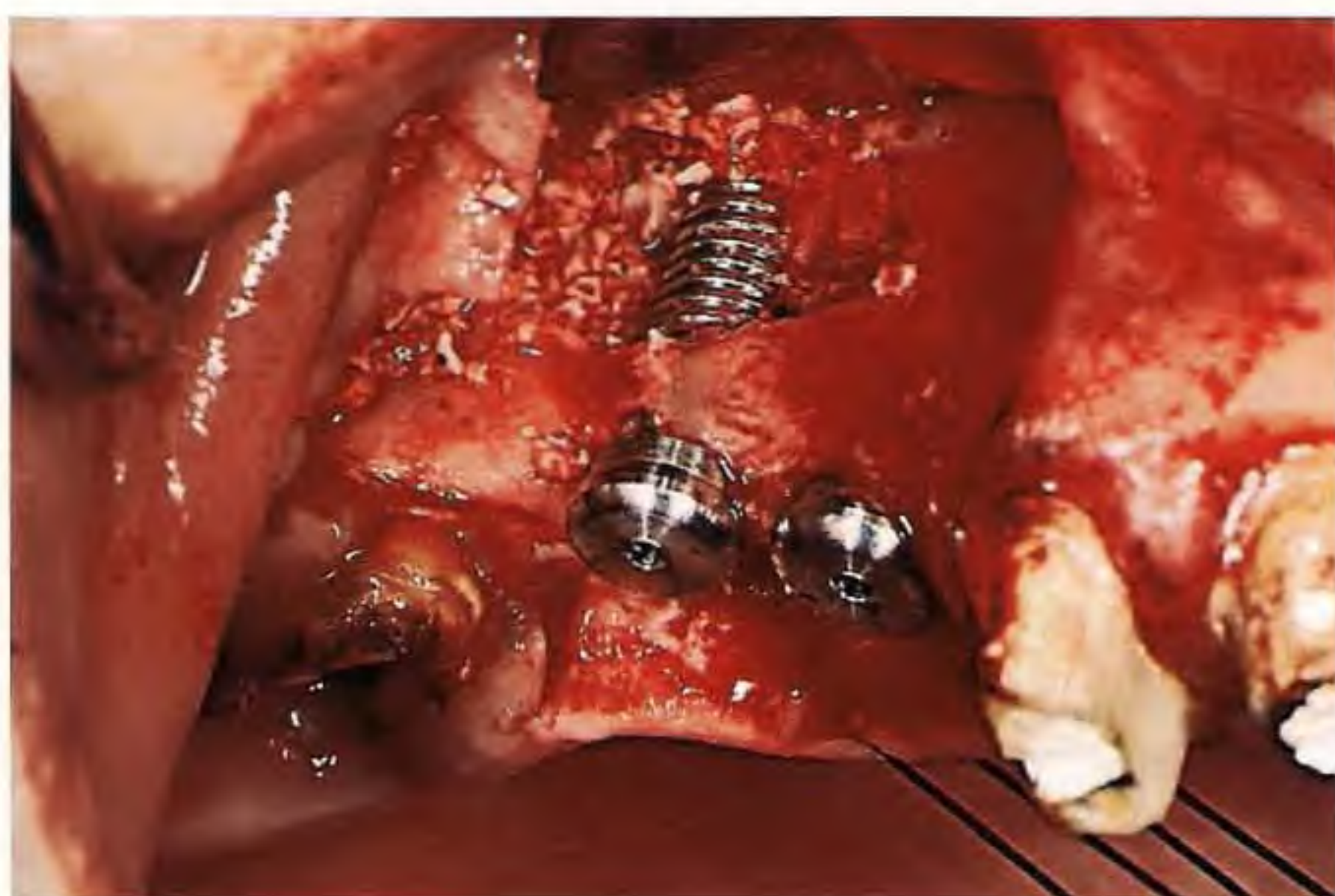


Fig 9-26 Fenestration of the buccal cortical bone after positioning of the implant.

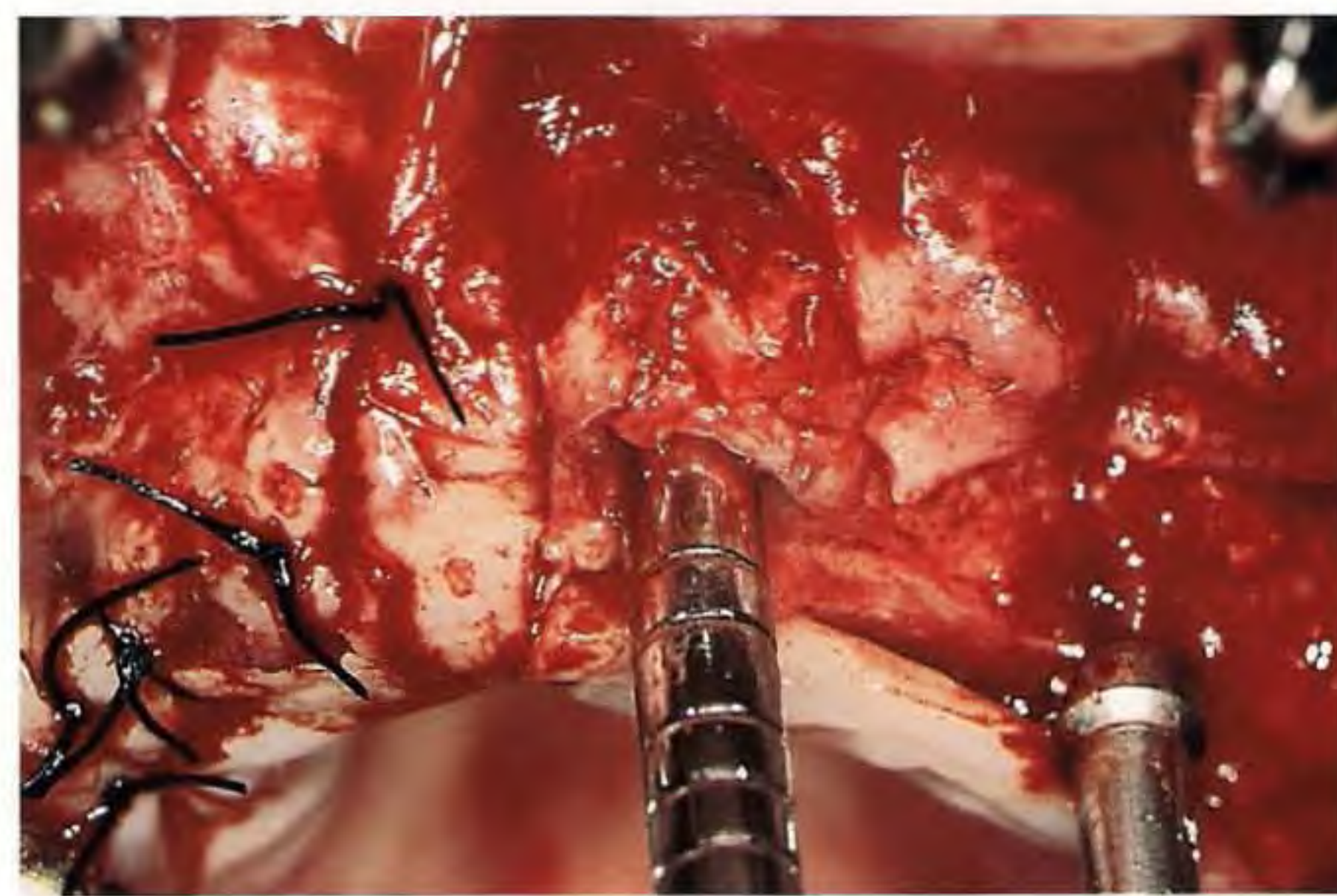


Fig 9-27 Technique for bone compression with an osteotome.

sive bone that extends from the left first premolar to the right first premolar. In the best conditions (Misch classes A and B), the edentulous arches, independent of their morphology, can be treated with the same standard procedures.

The density of the bone, on the other hand, affects the surgical protocol and determines the choice of the type of implant. The maxilla,¹⁰³ in the anterior region and in correspondence with the premolars, is composed primarily of thin cortical bone and very trabeculated spongy bone (D2 and D3). This condition makes the preparation of the implant site easier. However, the surgeon must pay attention to the direction of the implant site preparations in these segments to avoid undesired lateral perforations, especially in the buccal cortex, which is porous and is not very resistant (Fig 9-26).

In the presence of D3 bone, the diameter of the drill for final preparation should be a little smaller than that used in the presence of D2 type bone. It is advisable to reduce the speed of the drill to less than 1,500 rpm to heighten tactile sensibility during preparation. Furthermore, great attention must be paid to the control of the direction to avoid overpreparation of the hole itself, which would compromise the primary stability. To increase the stability of implants, it is always a good idea to use the apical part of the fixture in the thin cortical bone of the nasal or sinus cavity.

To place a screw implant, the use of a handpiece with a torque that can be regulated up to 50 N is indispensable; a manual screwdriver should never be used. Indeed, if an implant is manually screwed into spongy bone, the wavy movement caused by the rotation of the arm could cause overpreparation of an elliptical form that could compromise the primary stability of the implant. In spongy bone, it could be advantageous to use implants with treated surfaces and in this way increase the contact surface with the bone.^{104–107}

In the distal zone of the maxilla, especially in patients with long-term edentulism, the bone is of minimum density with thin trabeculae; cortical bone is almost nonexistent (D4). The edentulous crest is often wide, but it has a reduced vertical height because of the presence of the maxillary sinus. The main difficulty for the surgeon, when working with D4 bone,¹⁰⁸ consists of gaining primary stability of the implant.¹⁰⁹ For this reason, the implant site should not be prepared with rotating instruments until the final dimension is obtained. Only a pilot drill, which serves to determine the length and angulation of the preparation site, can be used. To widen the implant site preparation, it is better to use bone compression techniques (Figs 9-27 and 9-28). For this purpose, use of osteotomes and a surgical hammer is particularly advised.

Once preparation has been completed, the implant must be screwed in at a slow speed with the handpiece and not with manual screwdrivers. Countersinking or tapping drills should never be used. Wide-diameter implants can be used, because they offer a greater bone contact surface.¹¹⁰

Because of these perceptive observations, the success rate in the distal zone of the maxilla has notably increased. In a clinical study performed in 2000, Bahat²⁰ reported a 95% success rate for 660 implants inserted in the distal zones of the maxilla.

Guidelines for Mandibular Implant Surgery

The most common area for mandibular placement of implants is between the mental foramina, which constitute essential points of surgical reference and can always be localized.¹¹¹ The implant must be placed no less than 2 mm from the mental

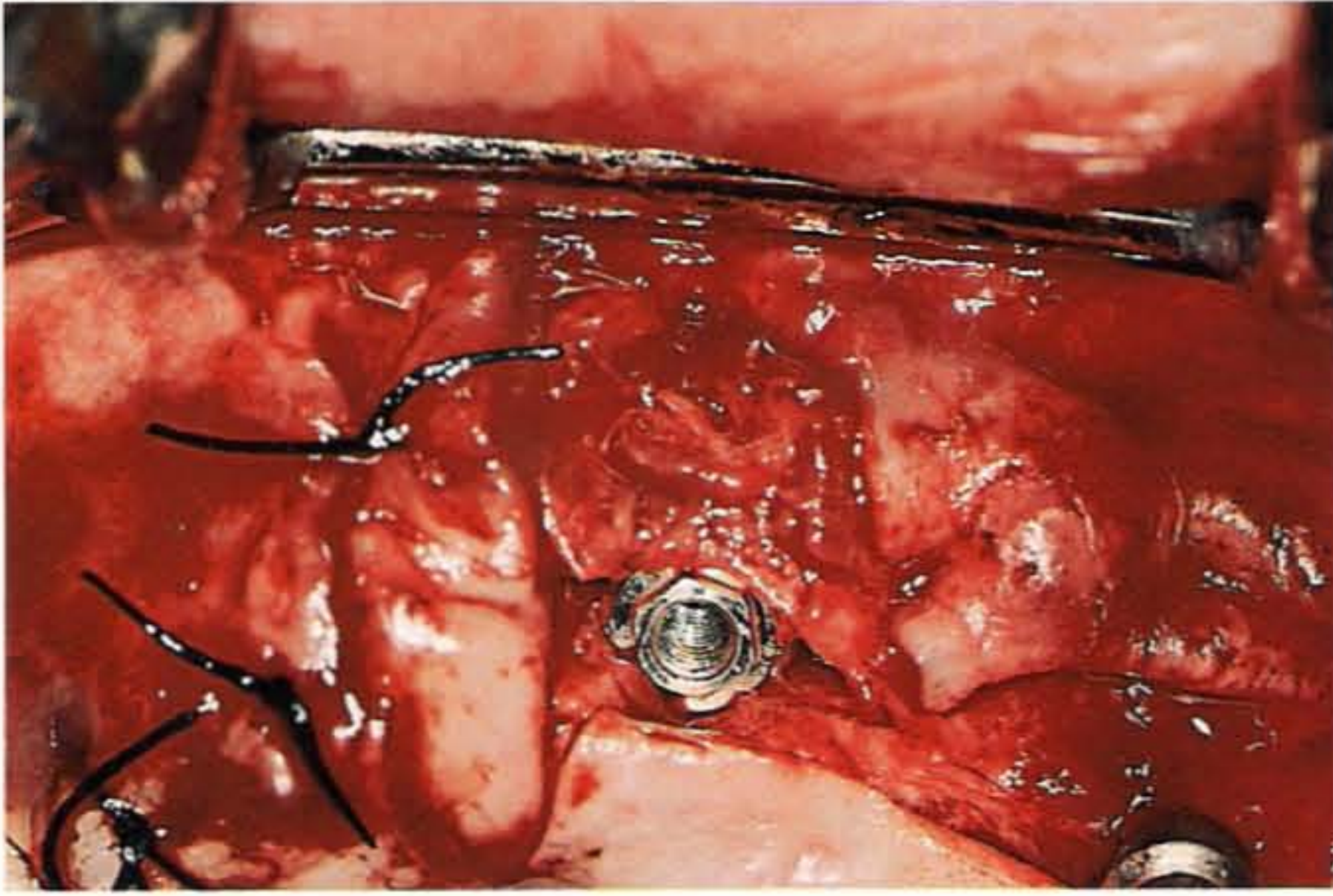


Fig 9-28 Implant in position.

foramina to avoid interference with the T loop of the nerve present on the anterior side. Because the bone in this zone is very compact (D1 or D2) and poorly vascularized,¹¹² it is necessary to avoid thermal and mechanical trauma during preparation of the implant site, which must always be carried out under abundant irrigation with cold physiologic solution. The difficulties are greater in the distal mental foramina because of the presence of the mandibular canal, which limits the quantity of available bone.

The only secure diagnostic methods of identifying the height and the width of the bone, as well as the location of the mandibular canal, are tomography and CT, the usefulness of which cannot be overlooked (Figs 9-29 and 9-30).

Another problem in the distal segments of the mandible can be the bone quality, which, under a hard but thin cortex, can be of type D4 and therefore unfavorable for primary stability.

Surgical Techniques for Bone Augmentation

In the cases of alveolar and basal bone resorption or bone discontinuity (Misch classes C and D), it is necessary to adopt reconstruction techniques¹¹³ with the aim of increasing the bone quantity.¹¹⁴⁻¹¹⁷ The aim of any skeletal graft is to repair the supportive function and guarantee the biologic reaction to mechanical stresses. The viability of a graft is determined by its capacity to integrate into the host organism and to promote the formation of new bone.¹¹⁸ The ideal characteristics that all graft materials should have can be summarized as follows:

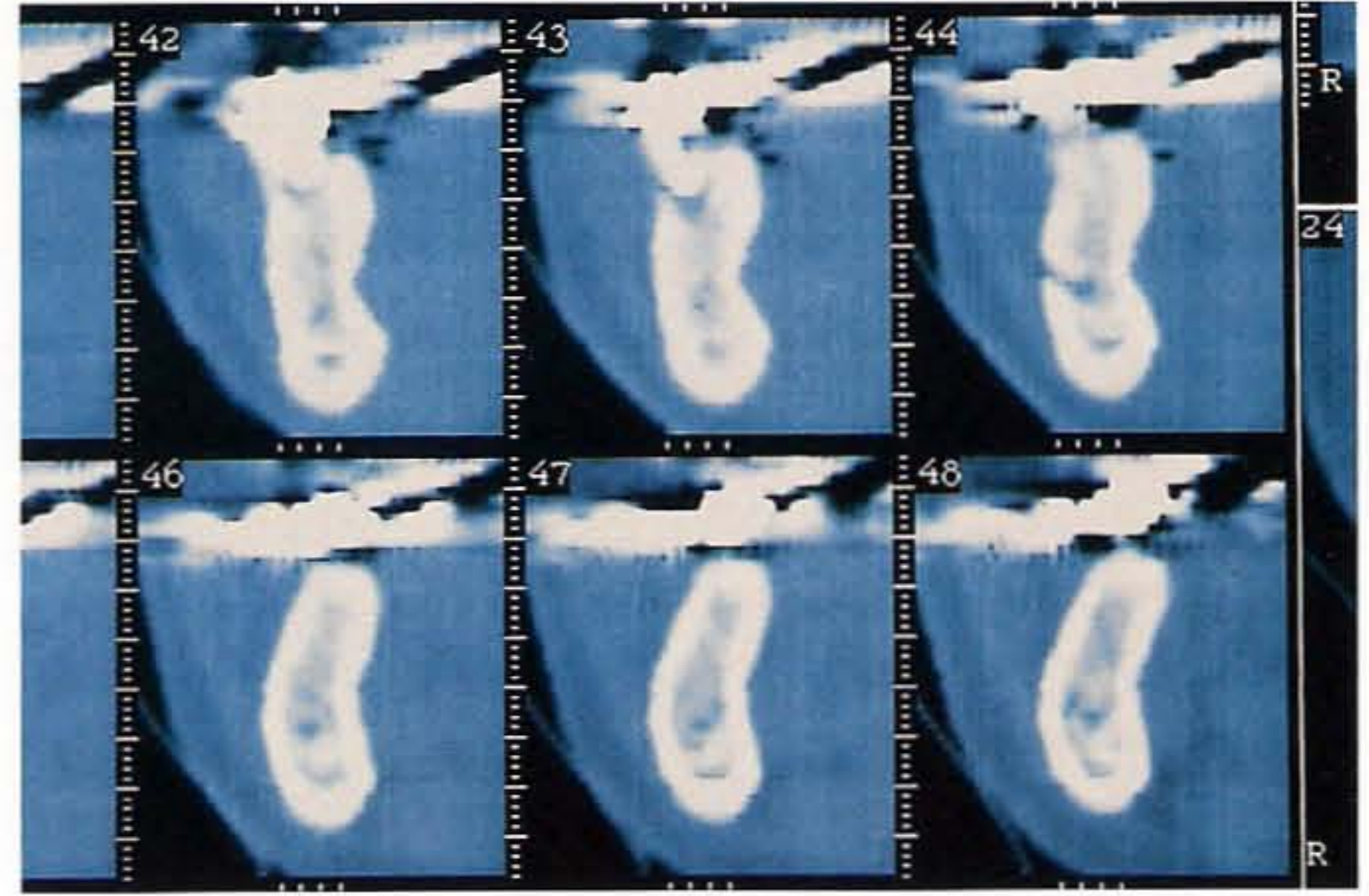


Fig 9-29 CT images of the mandibular canal.

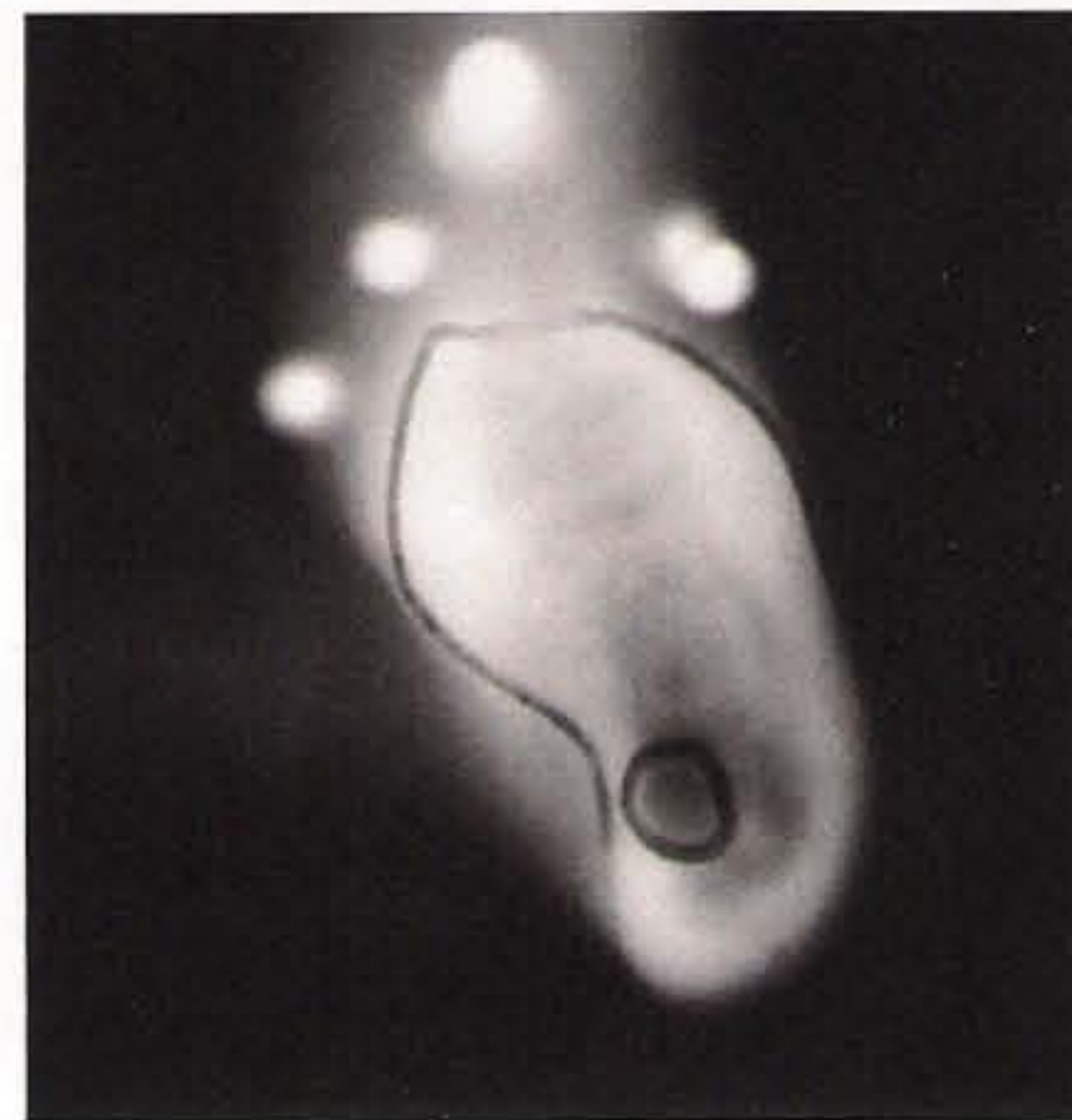


Fig 9-30 Tomographic scan of the mandibular canal.

- Biocompatibility
- Unlimited availability
- Osteoconductive and osteoinductive capacity (osteogenic potential)
- Primary structural integrity

Success of the reconstructive surgery depends on the capacity of the graft biomaterials to satisfy these conditions.¹¹⁹

Biocompatibility, osseointegration (the capacity to offer a rigid structure on which the new bone can grow), and osteoinductive capacity (the capacity to induce the differentiation of mesenchymal and progenitor cells in different cellular lines of the bone), represent, together with the level of vitality of the graft, the fundamental parameters on which the clinical merit of any graft material must be judged.^{120,121}

The vitality of the grafted bone guarantees those biologic characteristics that normally develop through the process of

remodeling in response to mechanical stress.^{120,121} When possible, in addition to these requirements, the graft material should have unlimited availability of graft material and a mechanical quality that implies a certain structural integrity from the moment of graft positioning in the receiving site.^{118,119,122}

Grafts of fresh autologous bone are considered the gold standard of graft biomaterials.^{107,118,119,122,123} The advantages of bone autografts have been confirmed by numerous experimental and clinical research studies^{124–126} that have shown their fundamental qualities:

- Healing through osteoconduction
- Healing through osteoinduction
- Transfer of progenitor cells from the vital bone

The osseous graft should only be positioned in a receiving site that is not affected by infective and or inflammatory processes.¹²⁰

The healing process of the osseous graft begins immediately when there is contact of the grafted bone with the receiving site.¹²⁰ La Trenta and collaborators¹²⁶ have shown, in a study on the beagle, that the relationships that exist between the graft and the receiving site significantly influence the maintenance of the initial volume of the grafts. Grafts positioned as inlays are subject to less osseous resorption than are those positioned as onlays. The greater surface of contact between the receiving site and inlay grafts offers the receiving site a greater number of bone progenitor cells, and revascularization can take place at more than one point of contact.¹²⁷ It is also as important to remember that inlay grafts are even better protected from microtrauma and micromovements.¹²⁶

It has been proved¹²⁶ that osseous grafts benefit from rigid fixation. A histologic and microradiographic study has shown that the benefits obtained from fixation are caused by early formation of osseous tissue that bonds the surfaces of contact between the graft and the receiving site. In the absence of rigid fixation, the union between surfaces is essentially made up of connective fiber tissue.

Depending on the surgical technique adopted, bone autograft can be used in the form of finely ground particles^{123,128} or monocortical or bicortical blocks¹²⁹; on its own or together with osteoconductive materials (mixed graft); or with membranes for regeneration. Particular bone grafts,^{123,128,129} whether pure or mixed, are advised for maxillary sinus augmentation and in association with titanium grids or membranes that can mechanically keep them in place (Figs 9-31 to 9-36). Block grafts are indicated to prevent vertical or horizontal resorption. Independently of their dimensions, they always have to be fixed with osteosynthesis screws and can be used for interposition (inlay) or for support (onlay) (Figs 9-37 and 9-38).

Depending on the quantity of bone necessary, an intraoral or extraoral donor site can be chosen. The intraoral sites that can be chosen are the chin¹¹⁵ (Figs 9-39 to 9-41), the maxillary tuberosity,¹²⁵ the body of the mandible body, and the lateral ramus of the mandible.^{115,130} The extraoral sites that are most suitable are the iliac crest,^{116,118} the tibia, the fibula, and the skull.

Two main disadvantages are associated with the extraction of autograft bone. The first is the necessity of a double surgical site in the same individual, with an increased risk of postsurgical complications and weakening of the donor region. The second limitation is the quantity of bone available for extraction, which is linked to the anatomic characteristics of the donor site.^{118,119,131}

The surgical techniques for osseous augmentation can be subdivided into two groups: outpatient surgery and major surgery.

Outpatient techniques

The following outpatient surgical techniques are used for osseous augmentation:

- Elevation of the maxillary sinus floor
- Reconstruction of the alveolar crest
- Onlay bone grafting of the alveolar crest
- Surgical expansion of the alveolar crest
- Vertical augmentation of the bone crest with distraction osteogenesis
- Guided bone regeneration around implants
- Vertical augmentation of the edentulous crest around implants
- Osteotome technique for minor elevation of the maxillary sinus floor

Elevation of the maxillary sinus floor

The posterior portion of the maxilla is considered the region in which the survival of implants is least predictable.^{20,132} The causes are the limited height, the poor quality of the available bone, and the intensity of occlusal forces to which implants must be subjected. To overcome these obstacles to the restoration of maxillary distal edentulous areas, it is necessary to increase the length and the number of implants. To this end, the maxillary sinus can be elevated and the subantral bone increased.^{133–136}

In 1980, Boyne and James¹⁰⁷ were the first to describe a surgical alternative to onlay grafting of the alveolar crest: A block graft harvested from the iliac crest is positioned as an inlay on the floor of the maxillary sinus after elevation of the sinus

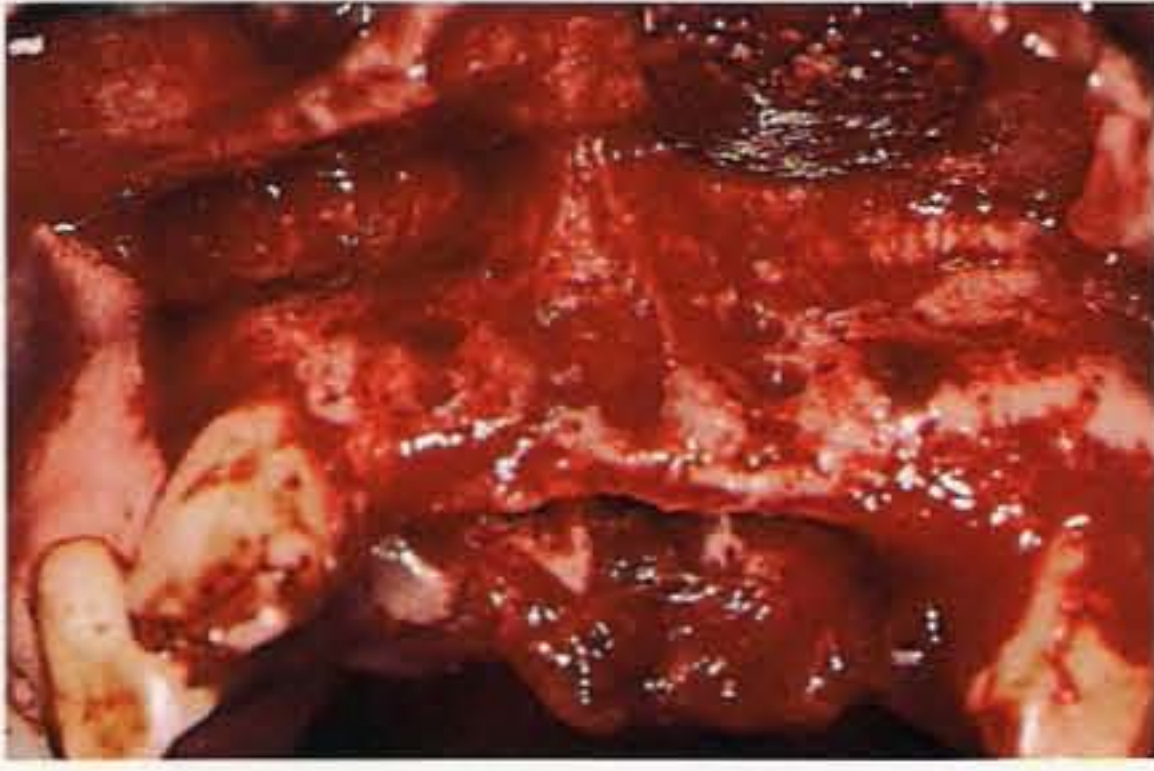


Fig 9-31 The mucoperiosteal flap is detached, exposing the osseous crest.

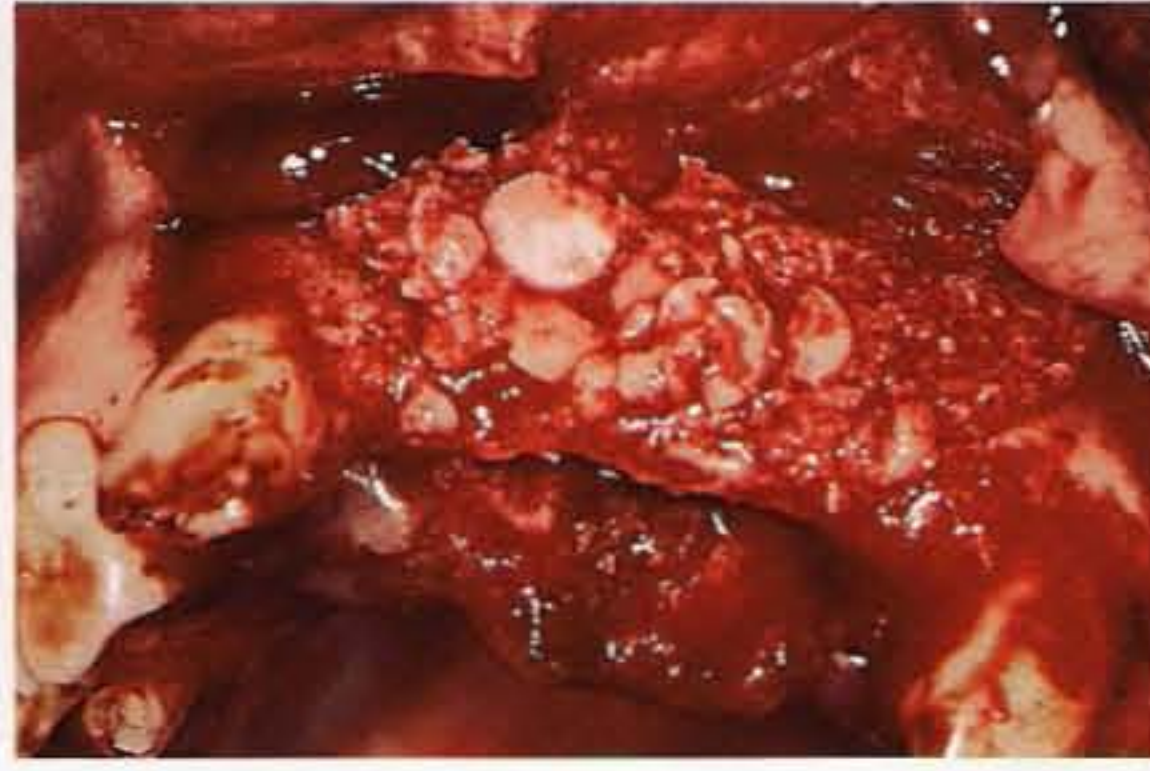


Fig 9-32 Autologous bone chips are placed.

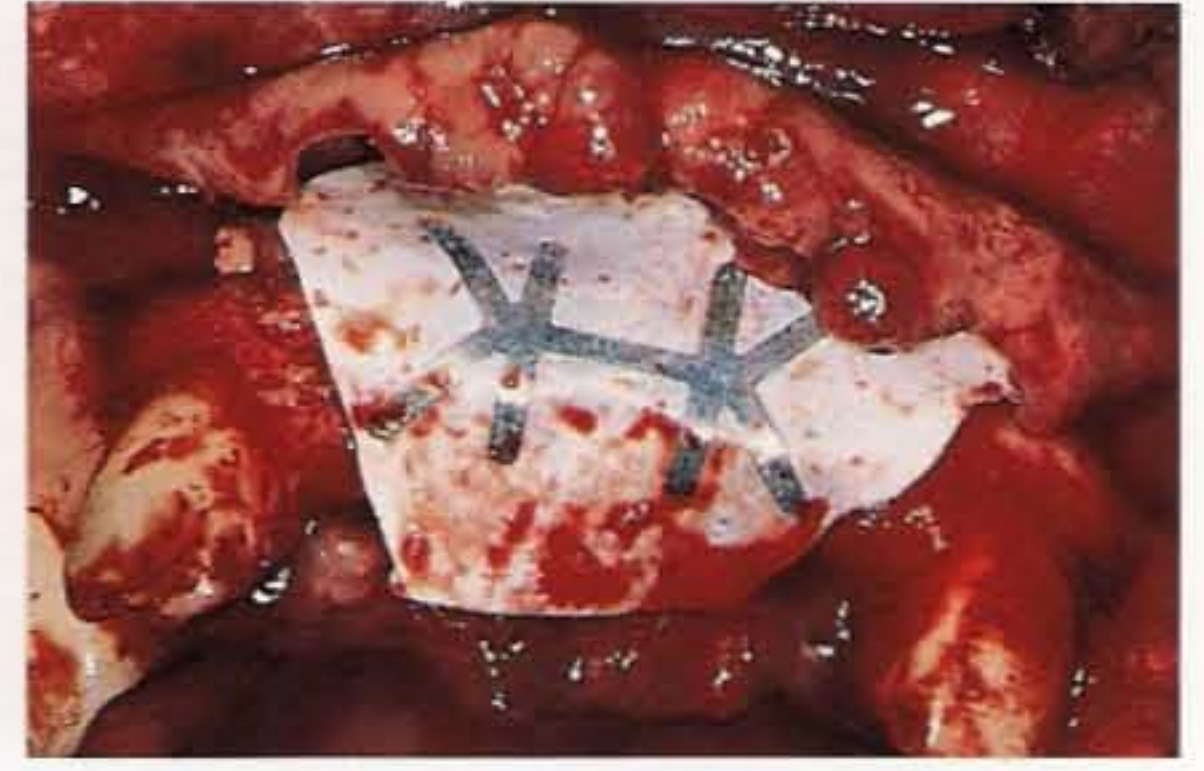


Fig 9-33 A titanium-reinforced polytetrafluoroethylene membrane is adapted.

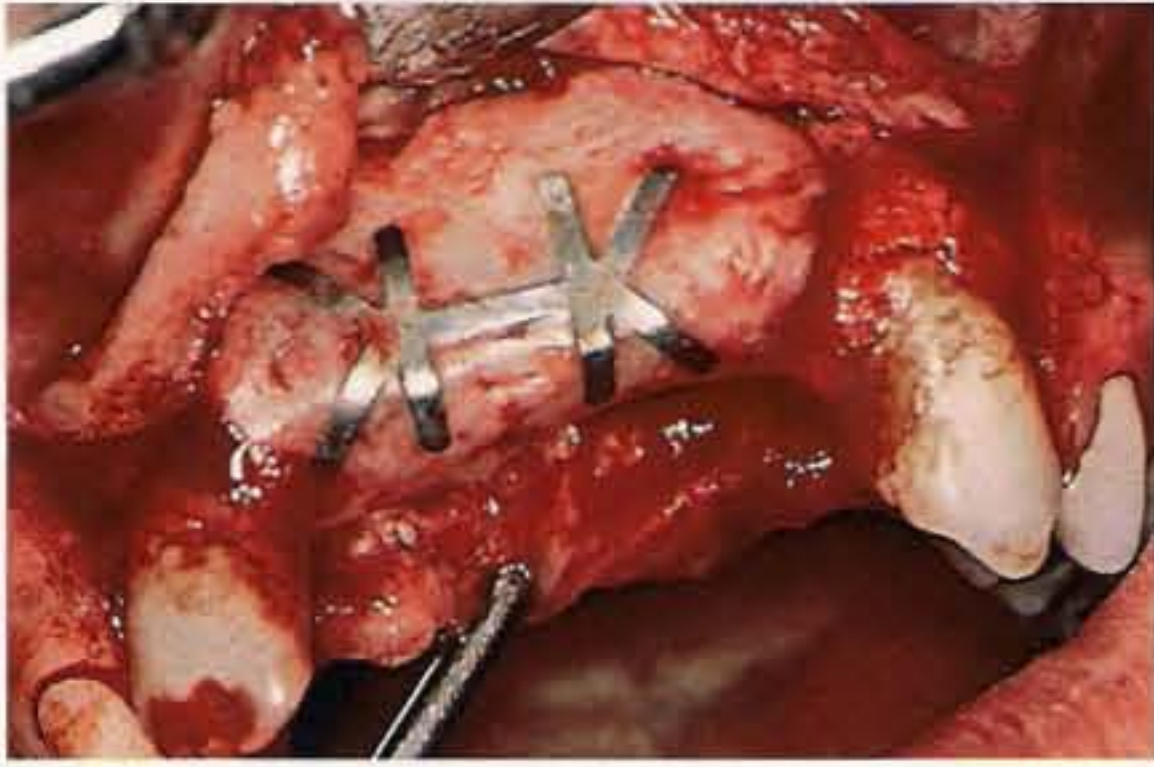


Fig 9-34 Surgical reopening is performed after 6 months.

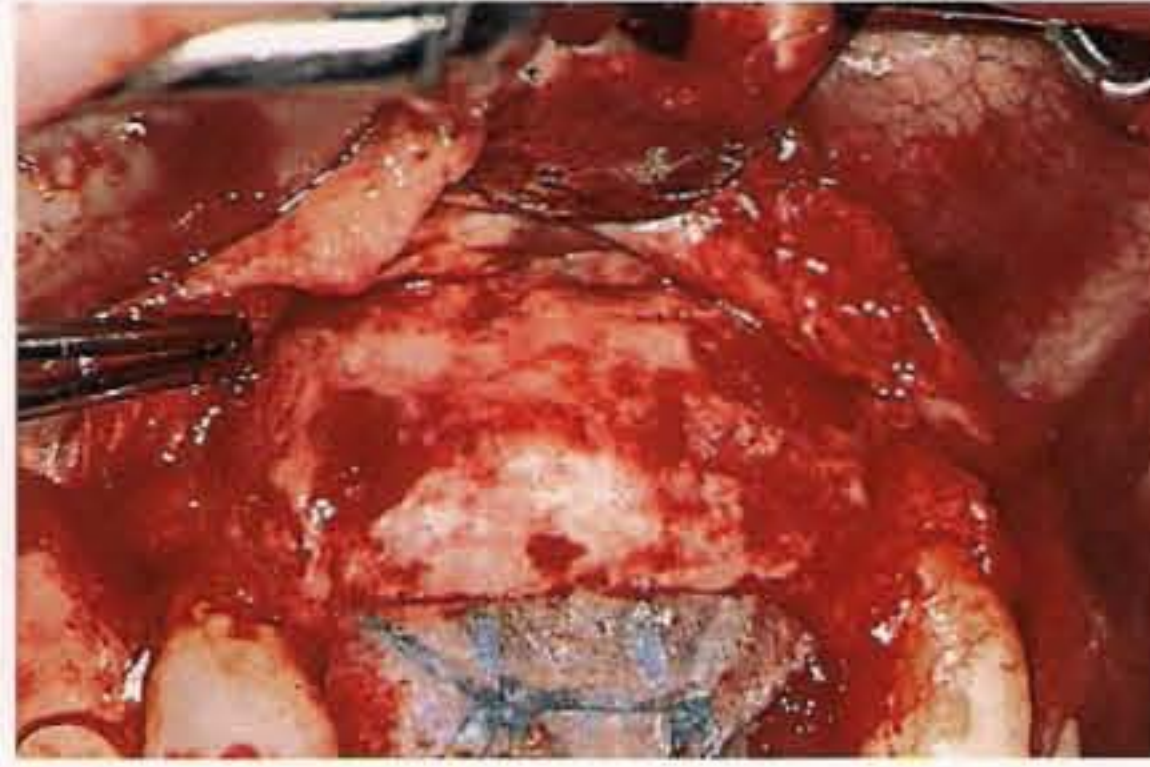


Fig 9-35 After removal of the membrane, the regenerated bone is visible.

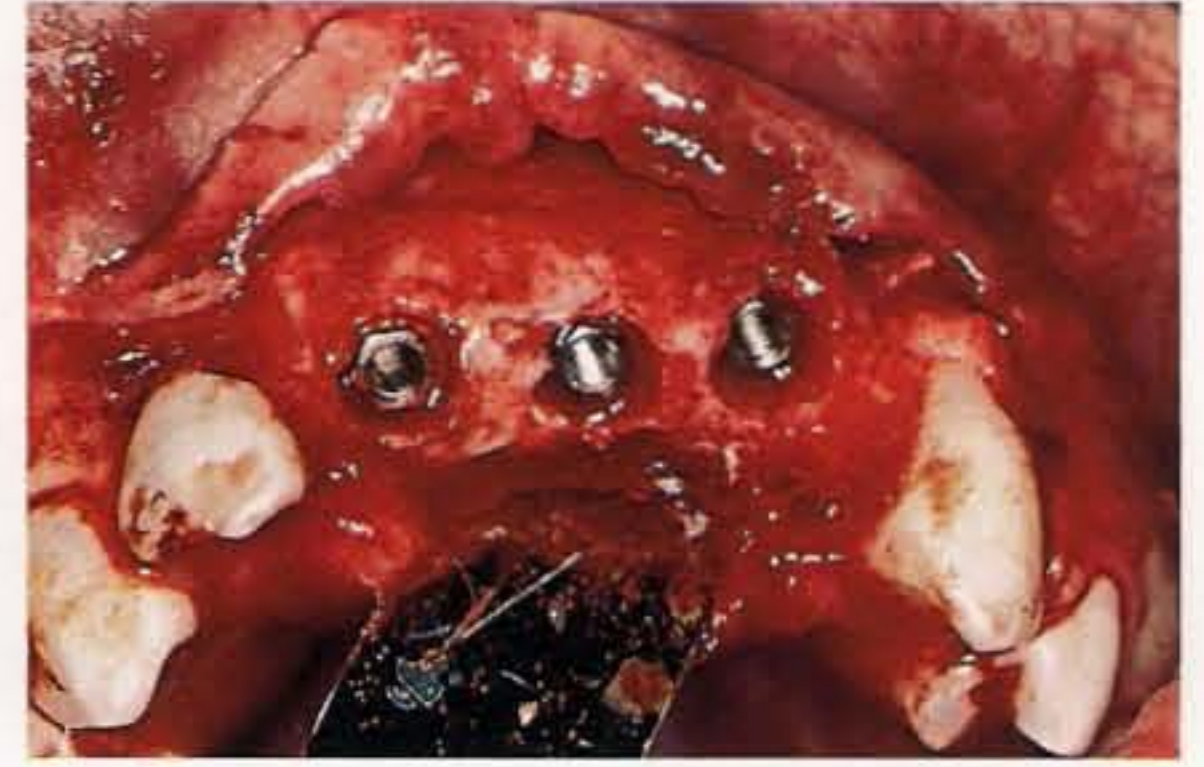


Fig 9-36 The implants are positioned in the regenerated bone crest.

Fig 9-37 (*right*) A bone inlay graft is positioned on the maxillary sinus floor and fixed with a plate and screws.



Fig 9-38 (*far right*) A bone inlay graft is positioned and fixed with titanium screws.

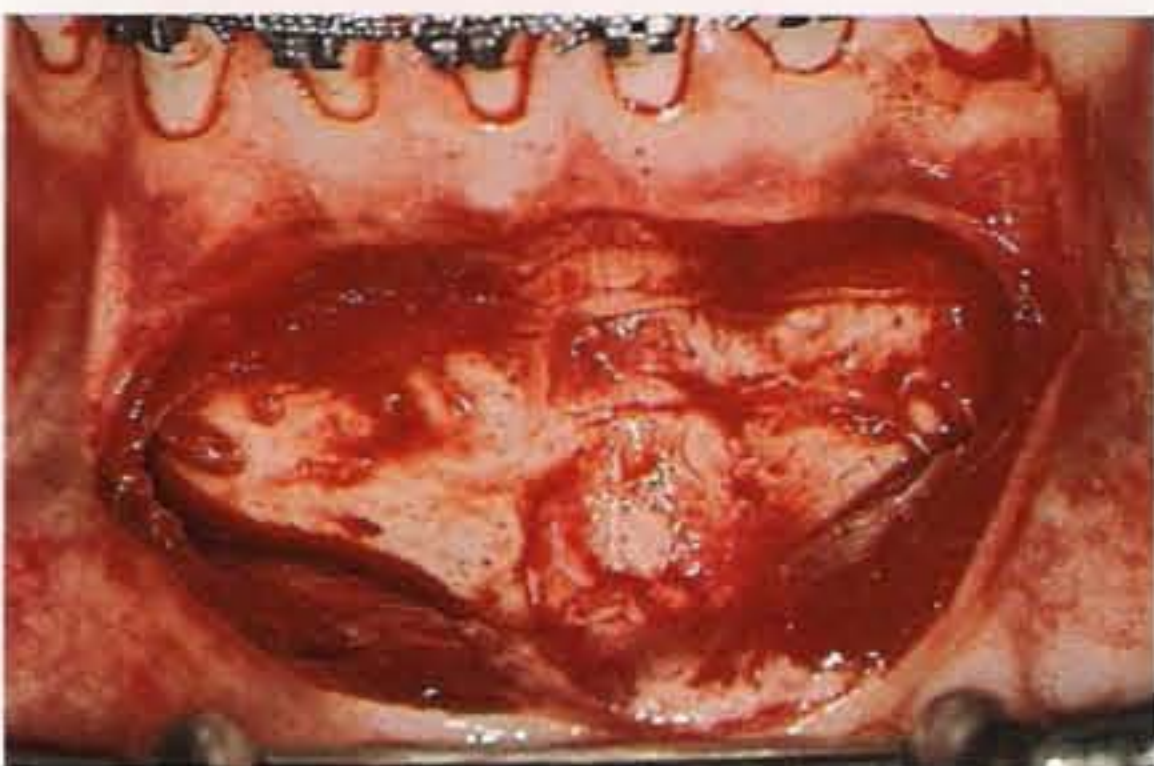
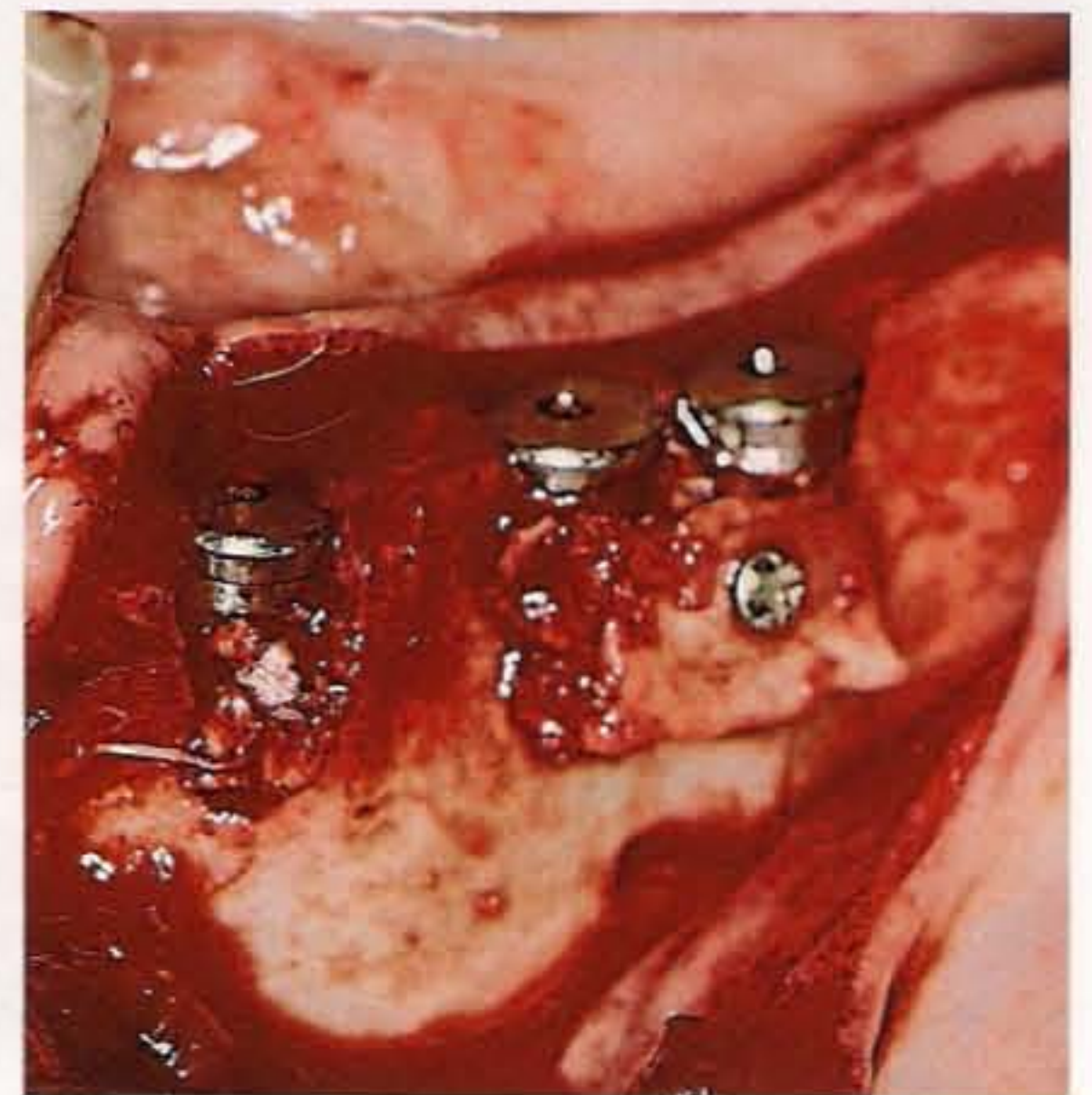


Fig 9-39 A mucosal incision is made to harvest bone for a graft from the mental symphysis.



Fig 9-40 The perimeter of the bone graft is outlined with an osteotome.



Fig 9-41 Bone has been harvested from the chin.

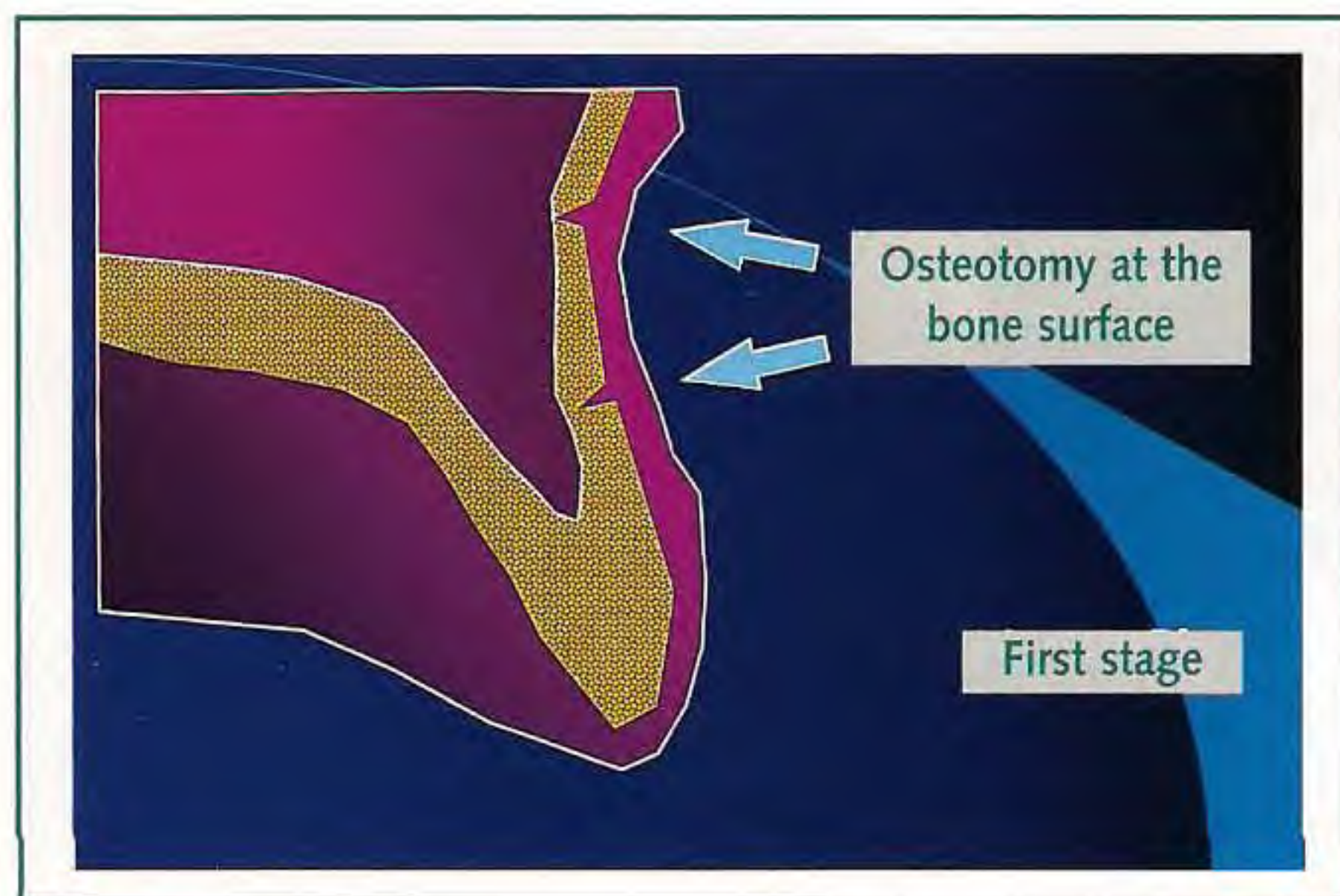


Fig 9-42 Trapdoor technique according to Tatum: buccal osteotomy for access to the maxillary sinus.



Fig 9-43 The osteotomy is initiated. Note the integrity of the sinus mucosa.

mucosa. A possible small laceration of the sinus mucosa will not induce significant damage in the maxillary sinus; therefore, such as laceration does not constitute a contraindication to proceeding with the surgery.¹³⁷ Implant placement takes place 4 to 6 months after surgery. After 4 years of observation, all the implants were functional with 100% survival rate.¹⁰⁷ Other authors^{138–140} have obtained similar percentages of success using both block grafts and bone particles. Bone grafts harvested from intraoral sites, the mandibular ramus,¹³⁰ and the mental symphysis^{141,142} have shown an implant success rate of 100%.

The two-stage procedures require a waiting period of 4 to 6 months, depending on the type and the form of the grafted bone (blocks or particles).^{143–146} In 1998, a clinical, histologic, and histomorphologic¹⁴⁷ study was conducted to evaluate the formation of new osseous tissue after grafting with different biomaterials for elevation of the maxillary sinus. A two-phase surgical procedure was used. The autografts were harvested from the iliac crest or from the mental symphysis and positioned as blocks or in particles; the mixed grafts were composed in equal parts of the patient's own bone and granular HA. The results of this research suggested that the architecture, composition, and geometric conformation of the grafts can influence the quantity of mineralized tissues present at the end of the healing period.¹⁴⁷ The membranous bone graft (mental symphysis), made up for the most part of cortical bone, both block and particulate, contained a greater quantity of hard tissue than the grafts of enchondral bone (iliac crest), constituted for the most part by spongy bone. These results are in accordance with those previously observed in animals by Smith and Abramson,¹⁴⁸ Zins and Whitaker,¹⁴⁹ and Hardesty and Marsh¹⁵⁰ and in clinical studies by Moy et al¹⁵¹ and Wallace et al.¹⁵²

The histologic analysis of particulate bone grafts revealed an osseous structure that was already organized in a trabecular system and a heightened and uniform vitality with the presence of numerous osteoblasts after only 4 months. Qualitatively, the findings were comparable to those of block grafts, healed, however, over a longer time (6 months). A smaller percentage of mineralized vital bone tissue was found in compound grafts after a healing period of 12 months. The use of a mix of heterologous material and autologous bone provides better results than simple HA but with a much longer period of healing.¹⁴⁷

To determine the best surgical technique,¹⁵³ it is essential to evaluate radiographically the height of the bone between the floor of the maxillary sinus and the external profile of the residual crest. In 1987, Misch¹³⁵ pointed out four different possibilities of treatment with relation to residual subantral (SA) bone:

- SA-1 available bone > 12 mm
- SA-2 available bone ≥ 10 and ≤ 12 mm
- SA-3 available bone > 5 and <10 mm
- SA-4 available bone ≤ 5 mm

In the first case, SA-1, it is possible to position the implants with a standard protocol. The therapeutic situation SA-2 necessitates a minor vertical augmentation. Cases classified SA-3 and SA-4 must be treated with an augmentation technique by means of a Tatum-type¹³⁶ lateral flap approach just above the residual alveolar bone (Figs 9-42 to 9-46).

In SA-3 situations, implants and the osseous graft can be positioned simultaneously if the residual bone allows good primary stability of the implants. In SA-4 cases, the technique first requires a graft, and then the implants are placed in a second procedure (Figs 9-47 to 9-67).

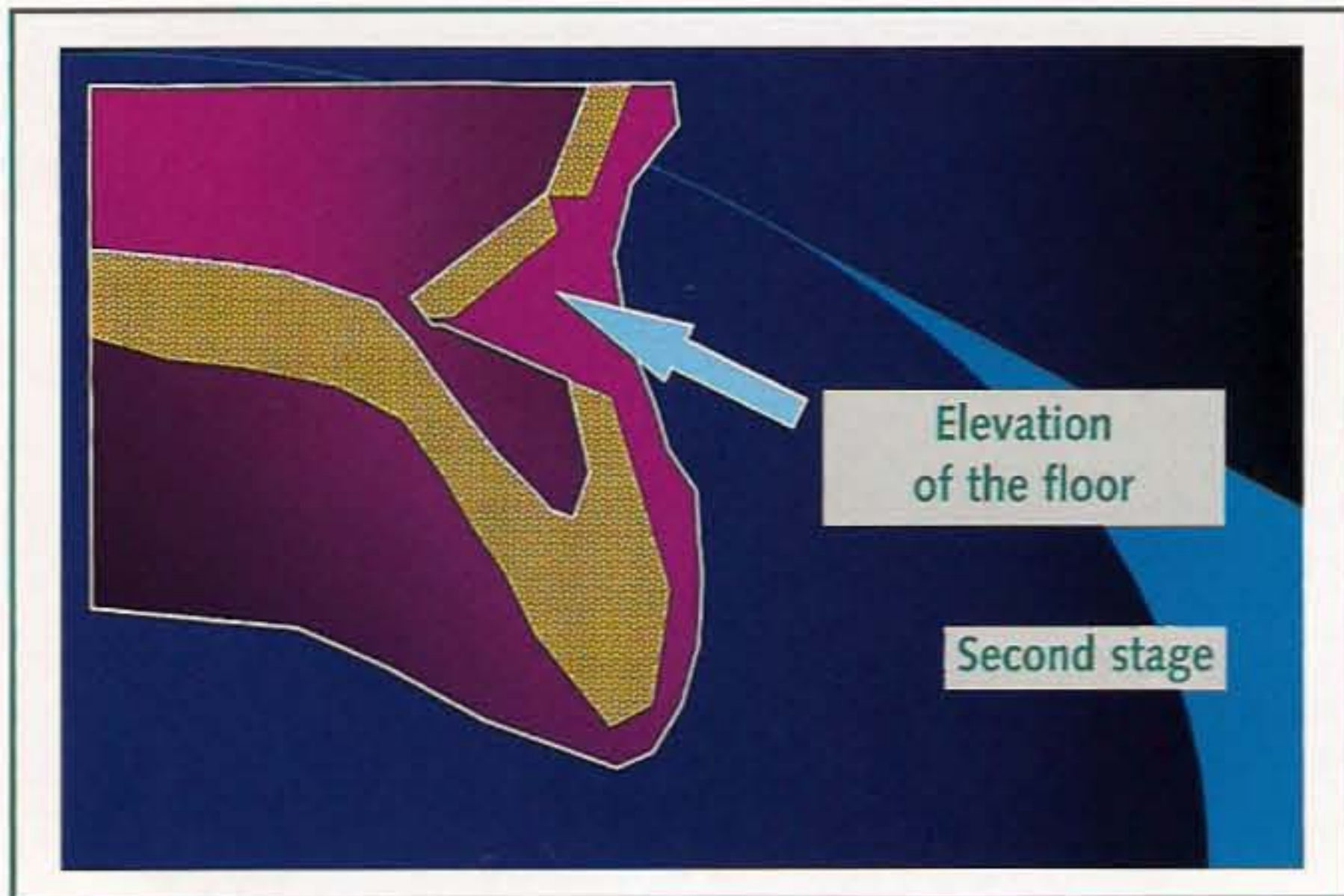


Fig 9-44 Elevation of the bone window.

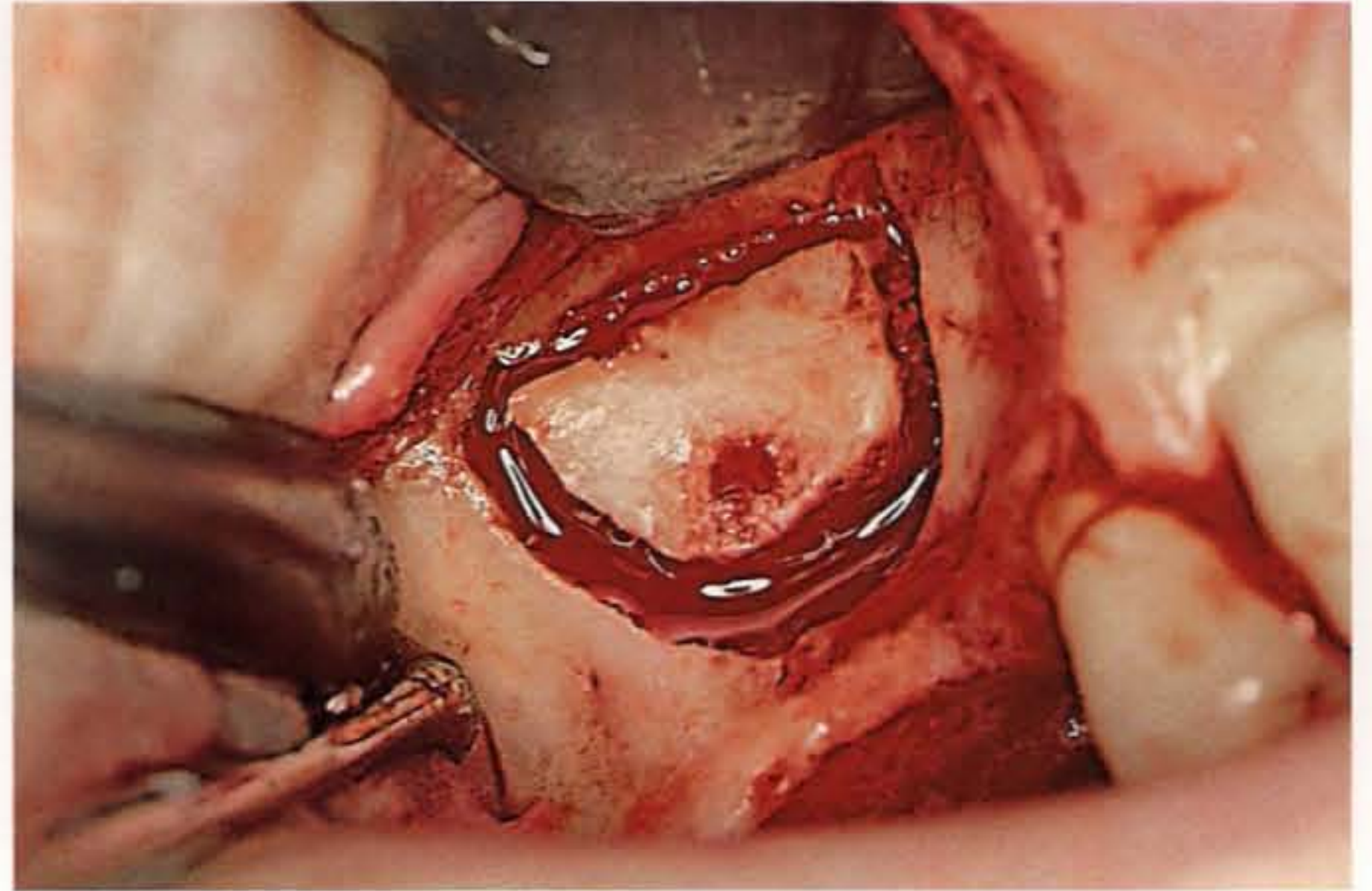


Fig 9-45 The osteotomy is completed to allow elevation of the bone window.

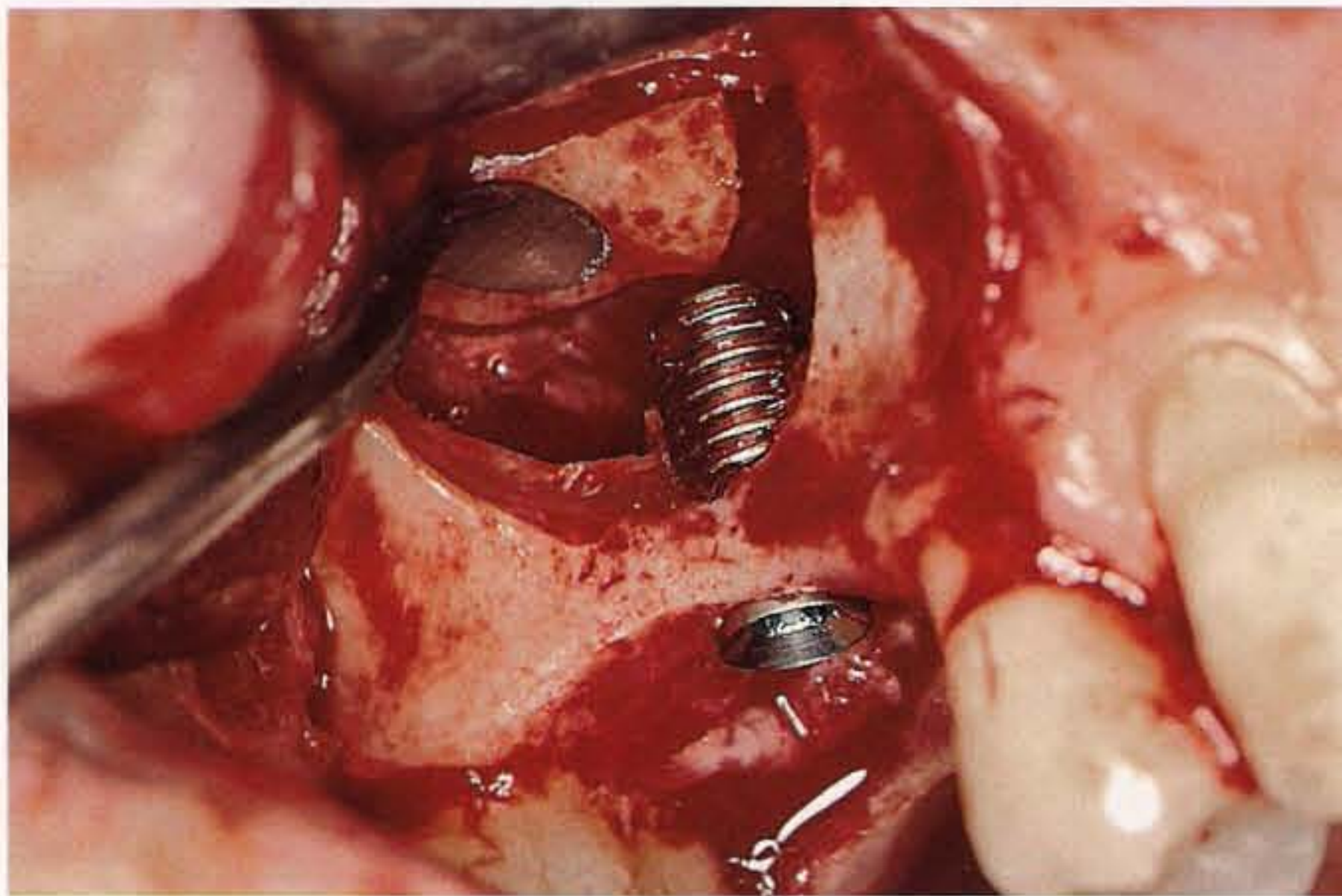


Fig 9-46 After the window is elevated and the sinus mucosa is raised, the implant is placed. Primary stability is obtained because of the residual bone of the sinus floor.

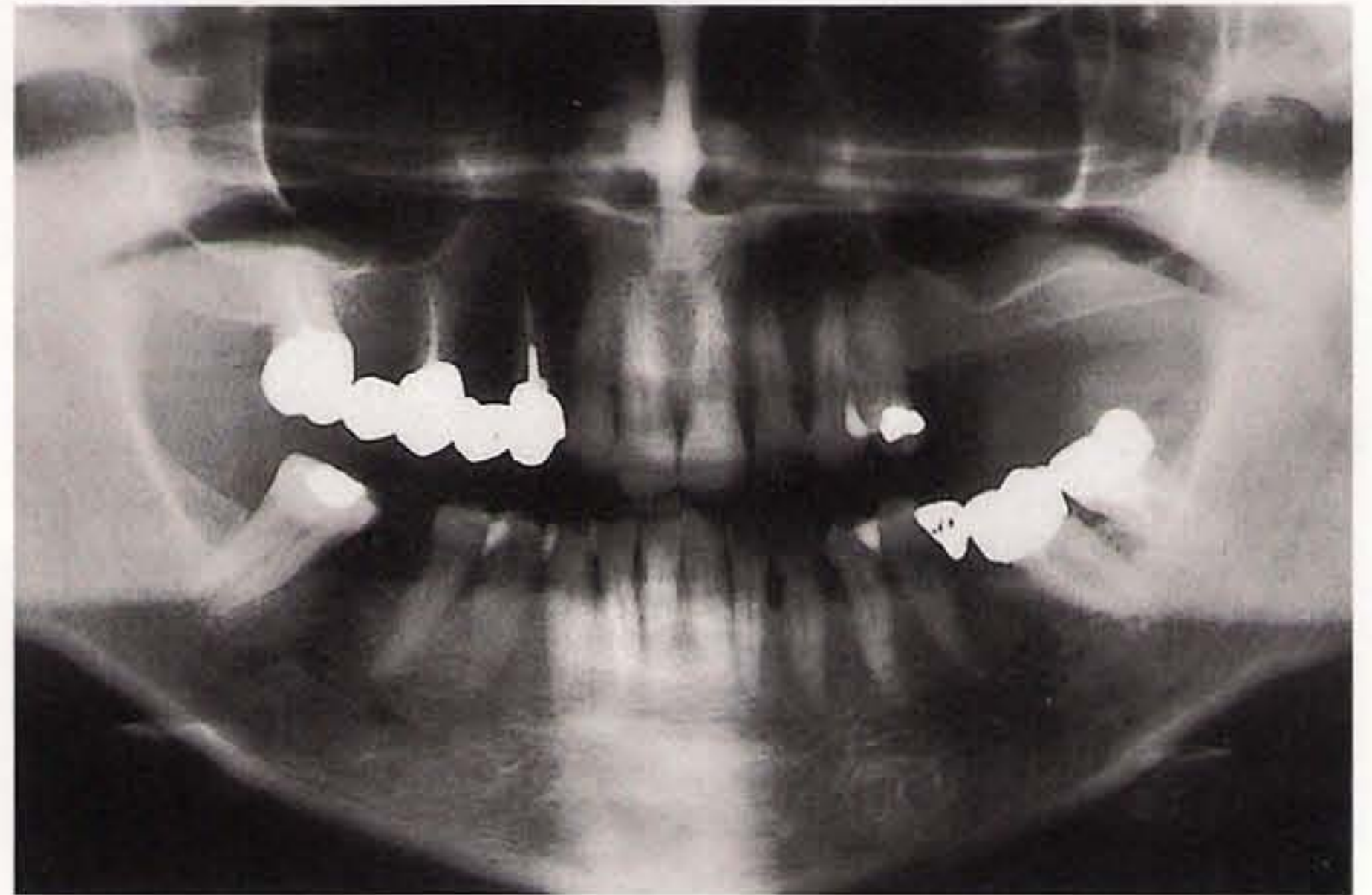


Fig 9-47 Panoramic radiograph of a posteriorly edentulous maxilla with insufficient basal bone.

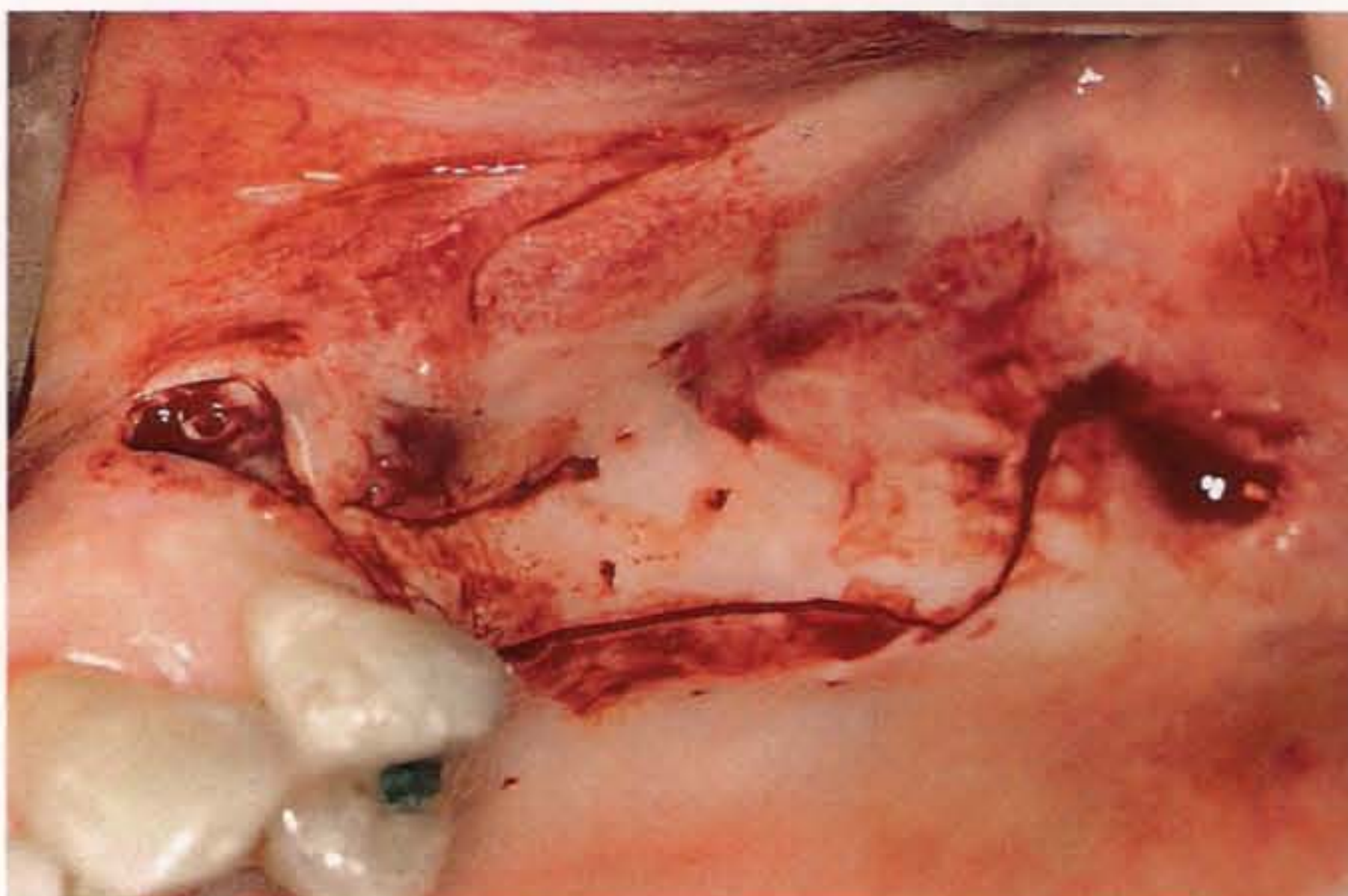


Fig 9-48 A trapezoidal surgical flap is raised for the maxillary sinus elevation technique.

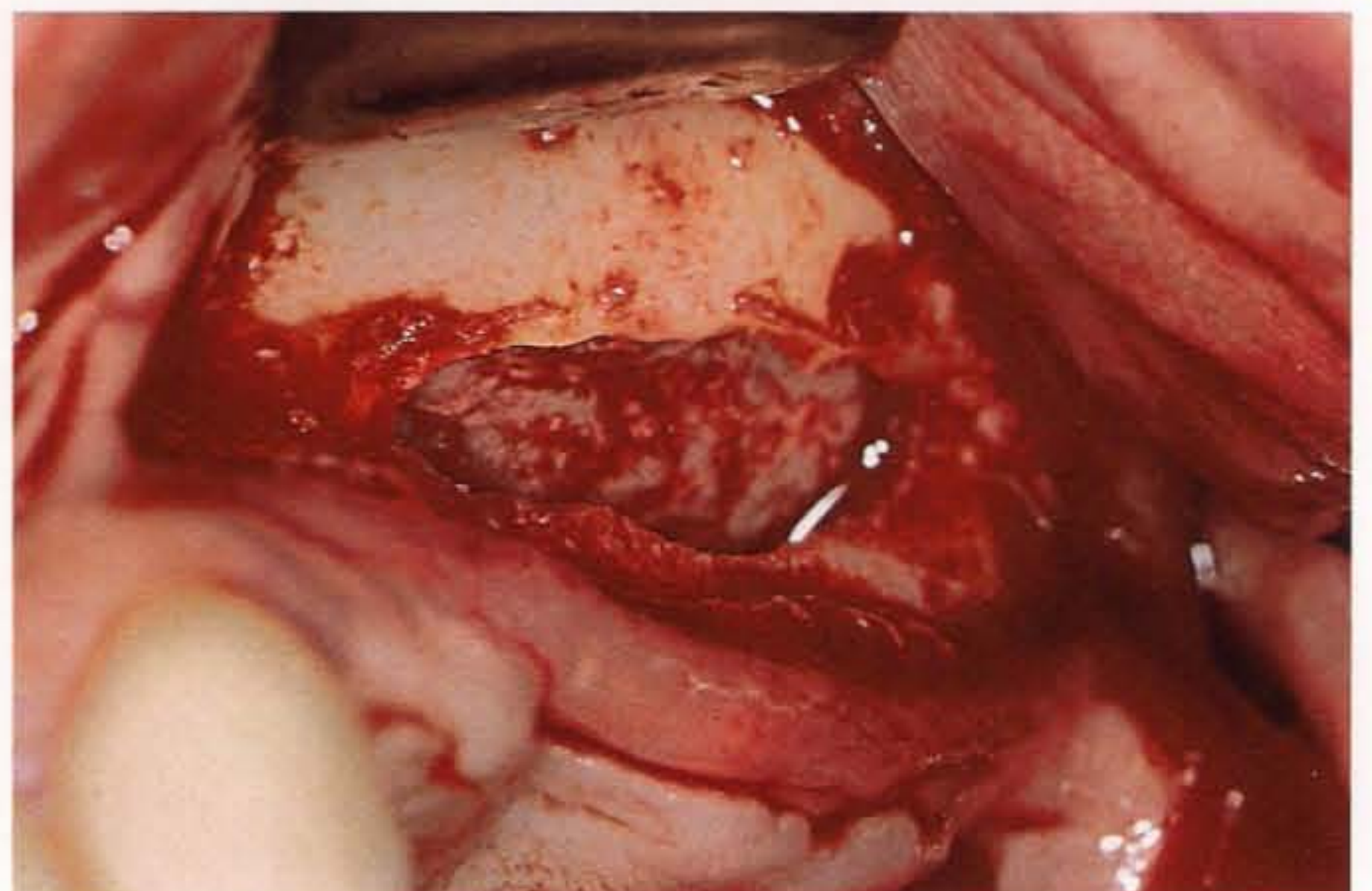


Fig 9-49 A trapdoor is created for access to the sinus.



Fig 9-50 A bone block has been harvested from the mental symphysis.

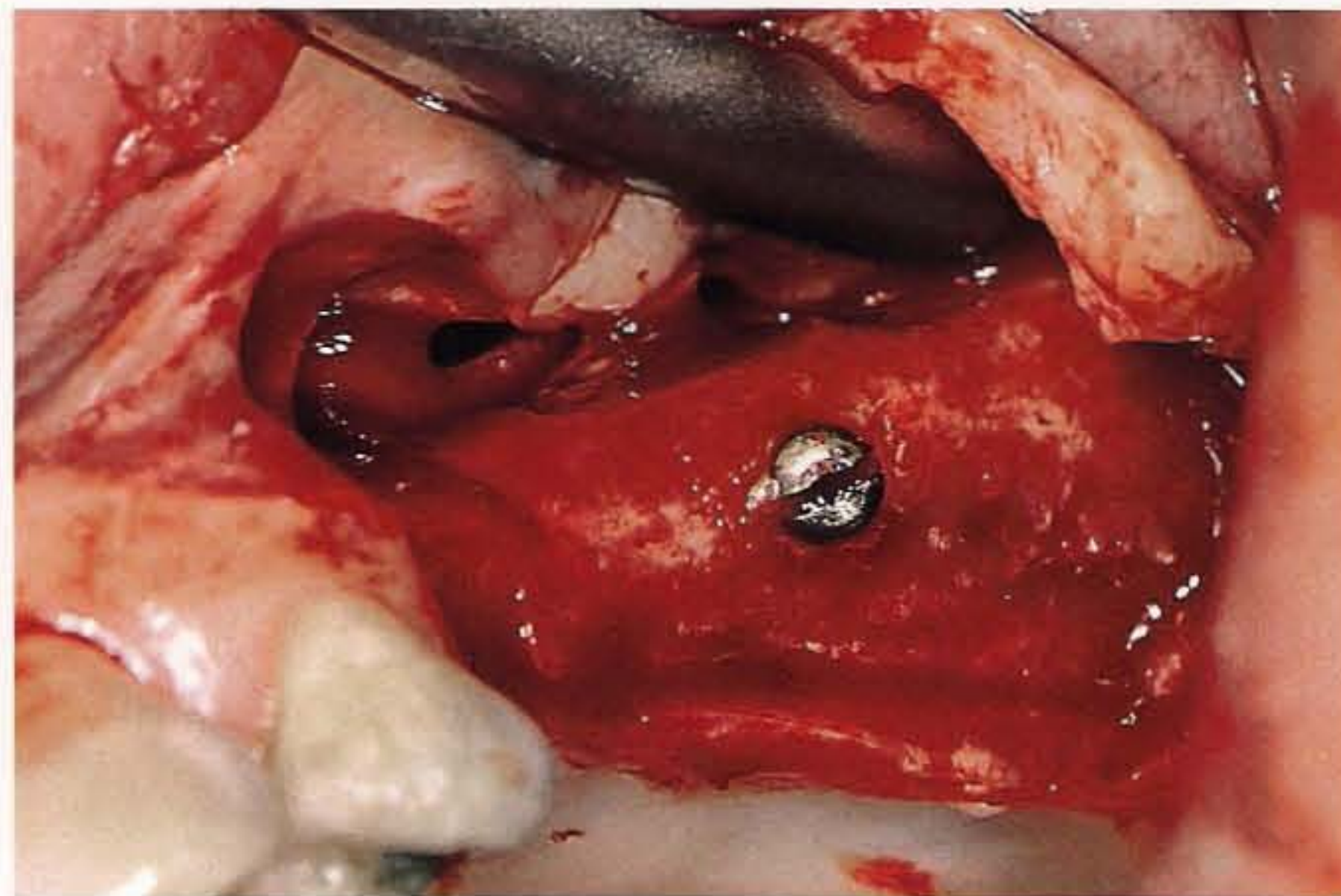


Fig 9-51 The bone block is placed in the maxillary sinus and then rigidly anchored to the sinus floor with titanium screws.

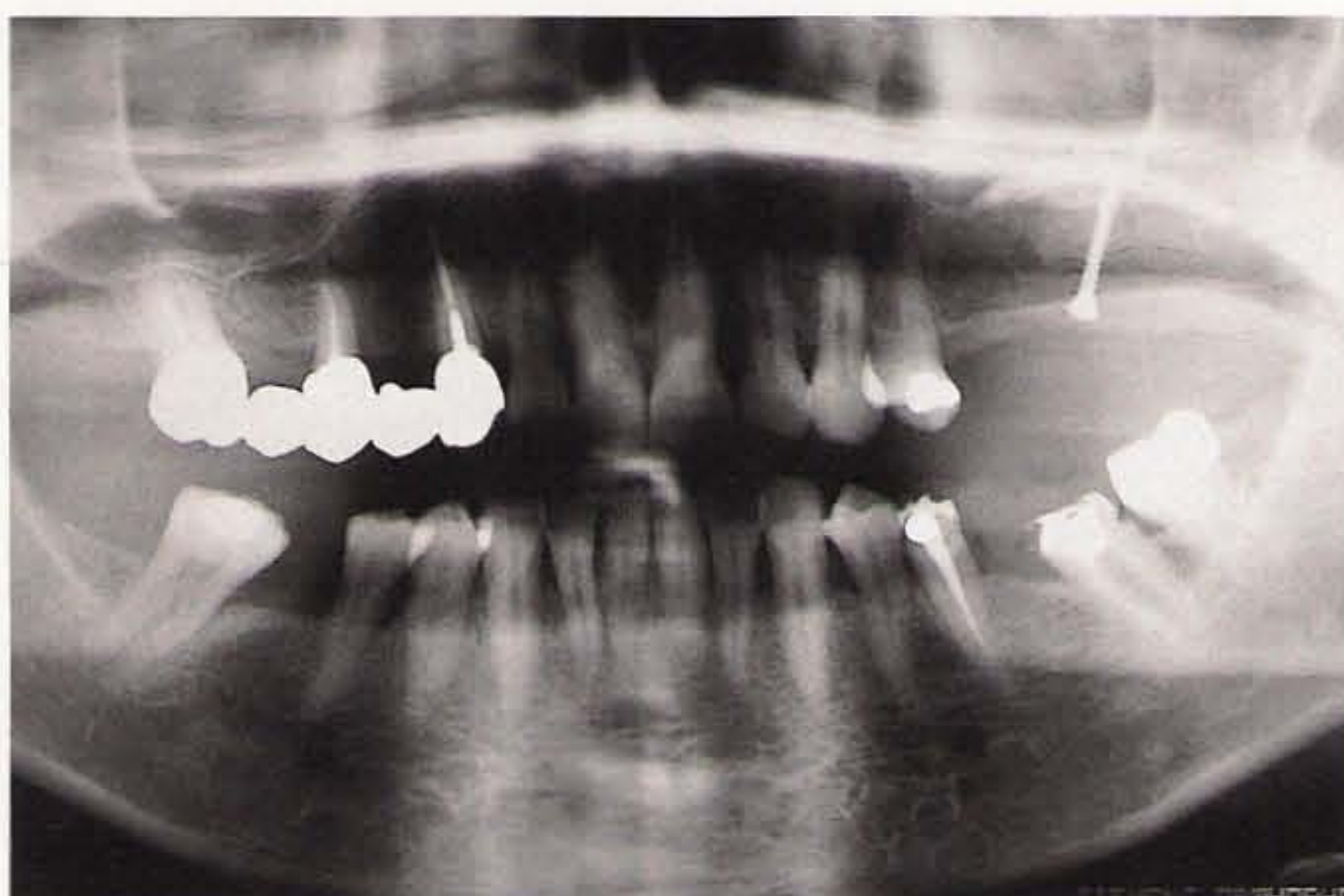


Fig 9-52 Control panoramic radiograph after 6 months. The grafted block, stabilized with screws, is clearly visible.

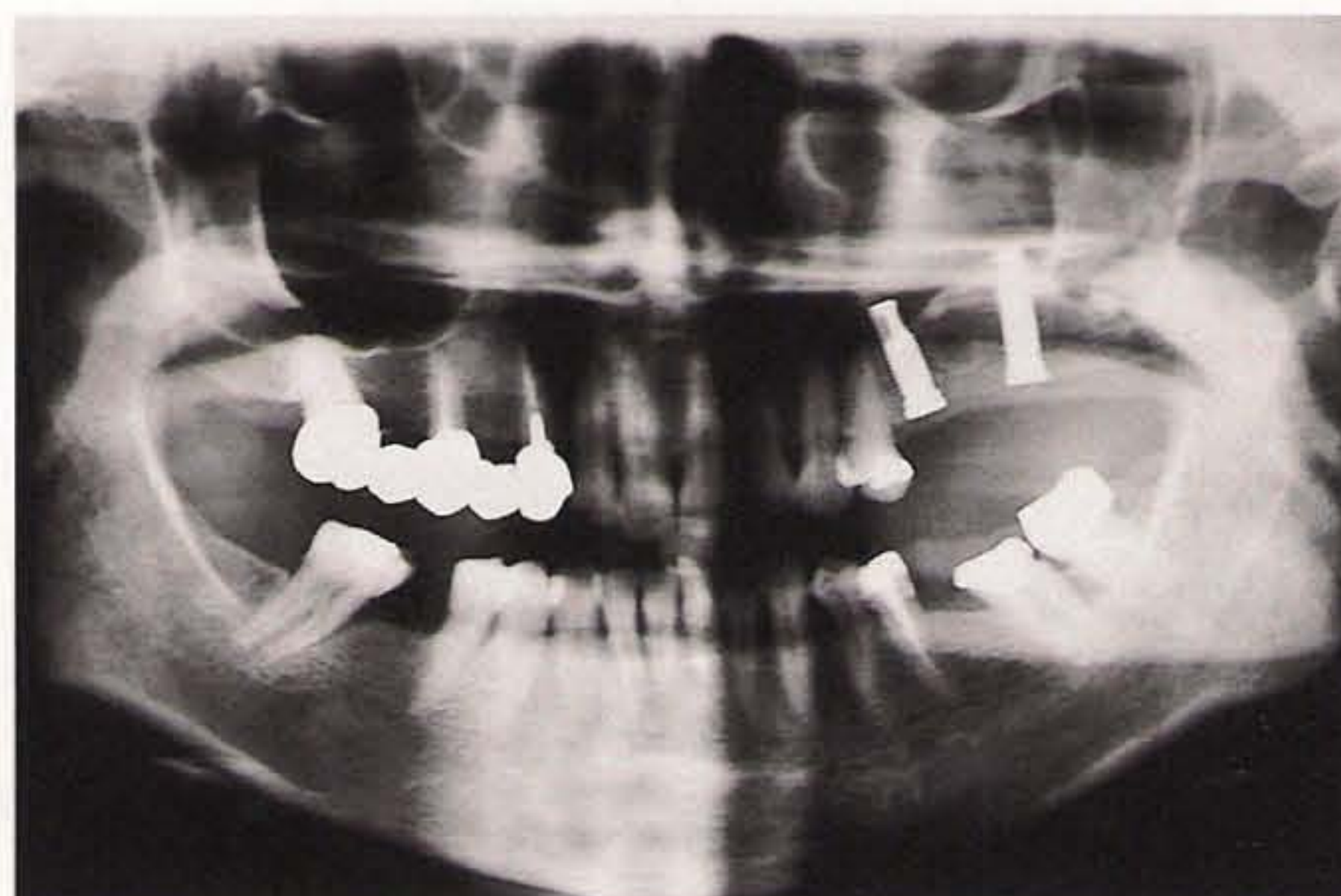


Fig 9-53 Panoramic radiograph made after placement of the implant.



Fig 9-54 Panoramic radiograph. The periodontally compromised maxillary left first premolar, first molar, and second molar must be extracted.



Fig 9-55 A radiograph reveals the limited bone quantity in the left sinus floor.



Fig 9-56 The edentulous crest is shown after the tooth extractions.



Fig 9-57 An osteotomy is performed for trapdoor access in the sinus.

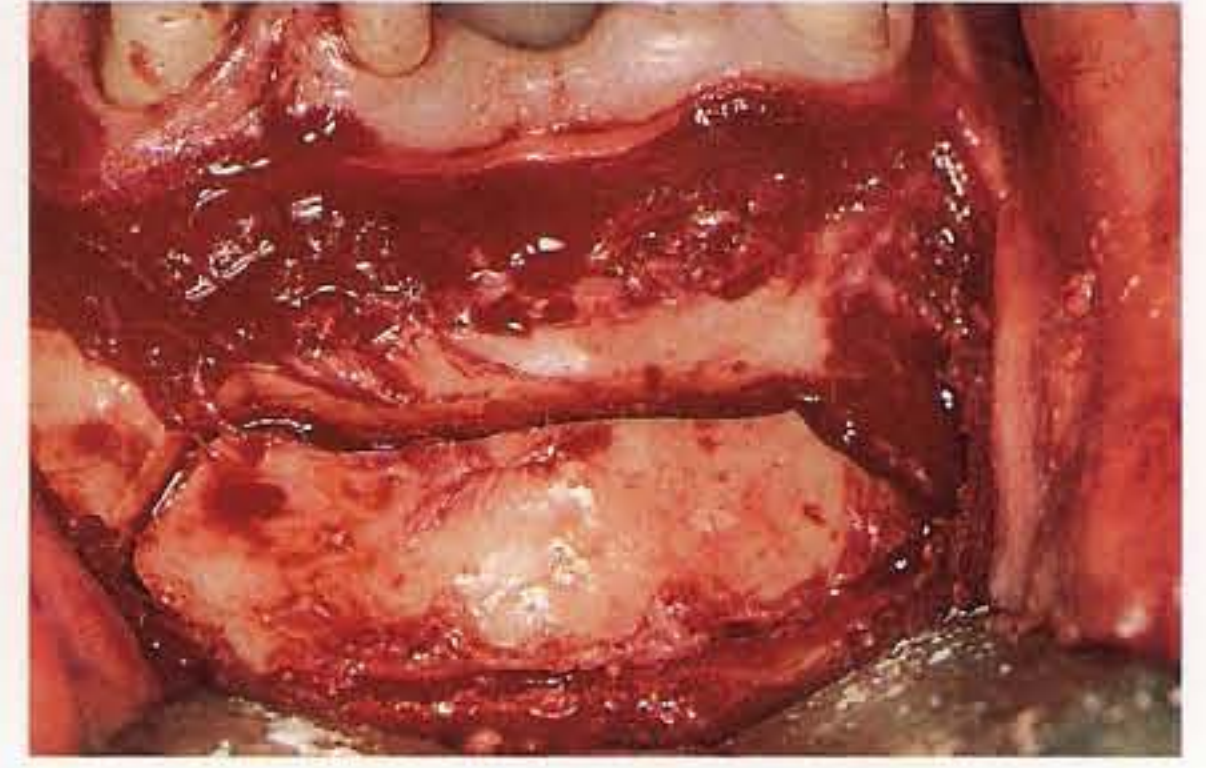


Fig 9-58 An osteotomy is performed to harvest bone graft tissue from the mental symphysis.

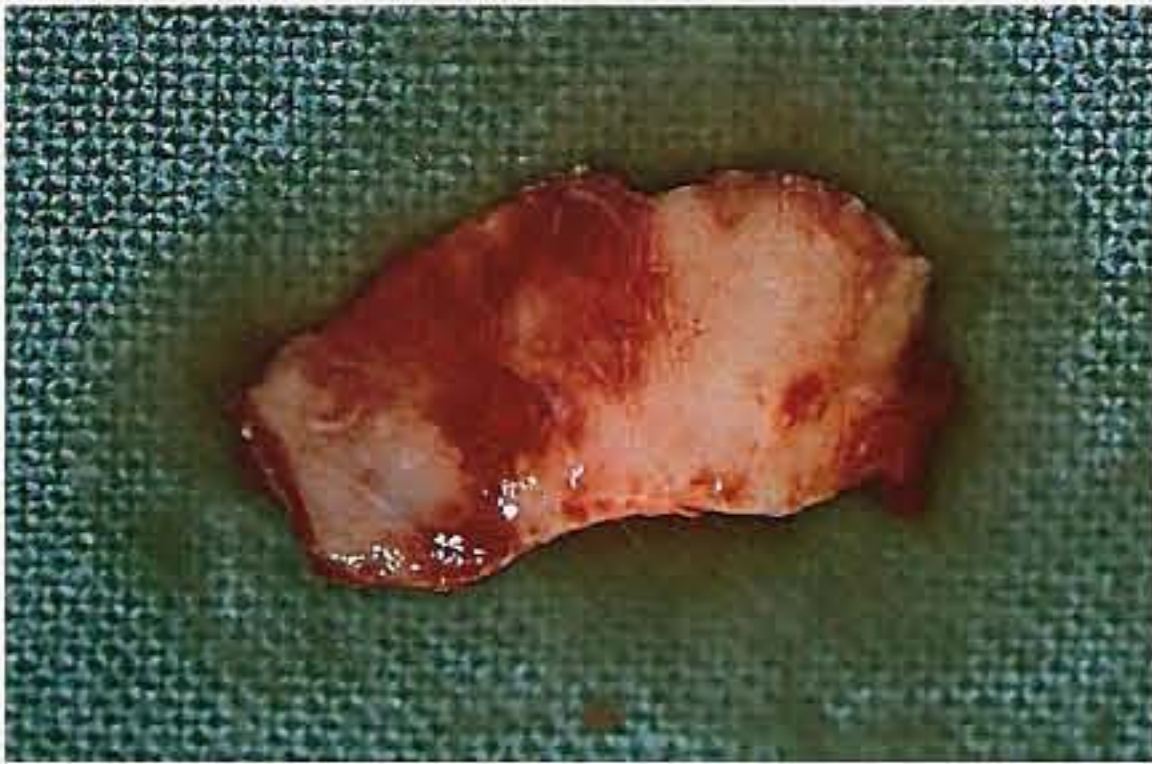


Fig 9-59 A bone block graft has been harvested.

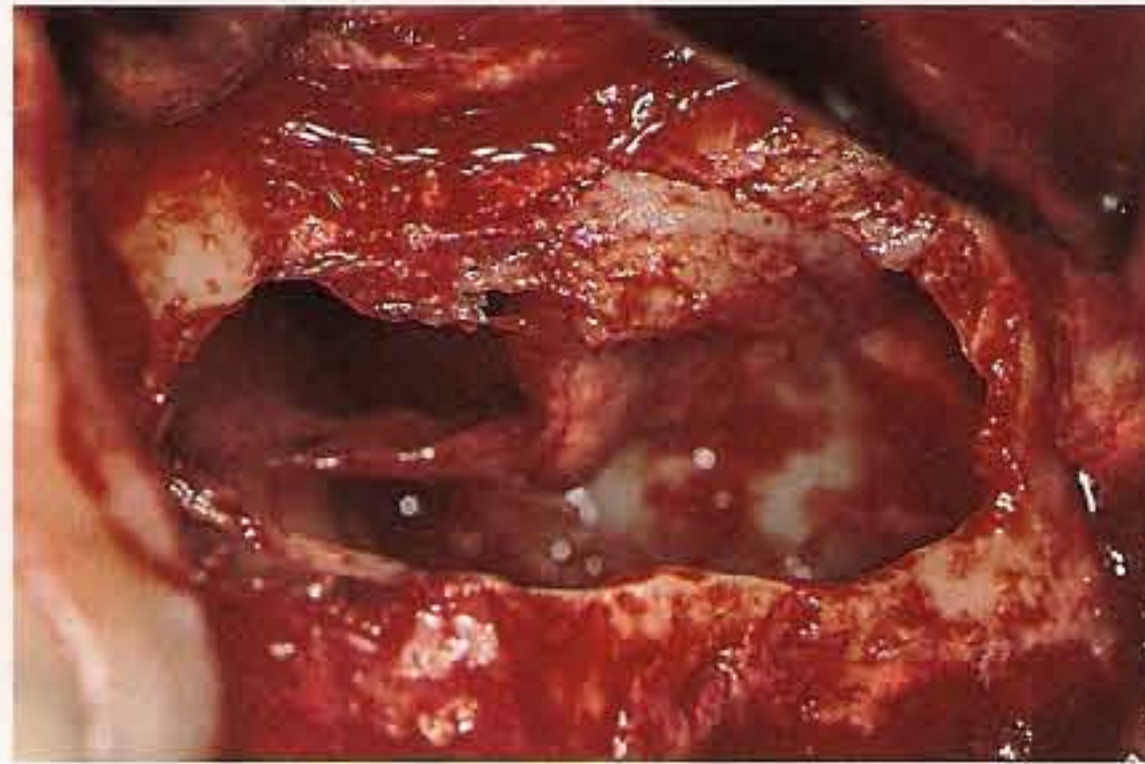


Fig 9-60 The sinus mucosa is perforated during the elevation procedure.



Fig 9-61 A resorbable membrane is placed in contact with the sinus mucosa wound.

Fig 9-62 (right) The block graft is inserted in the sinus cavity.

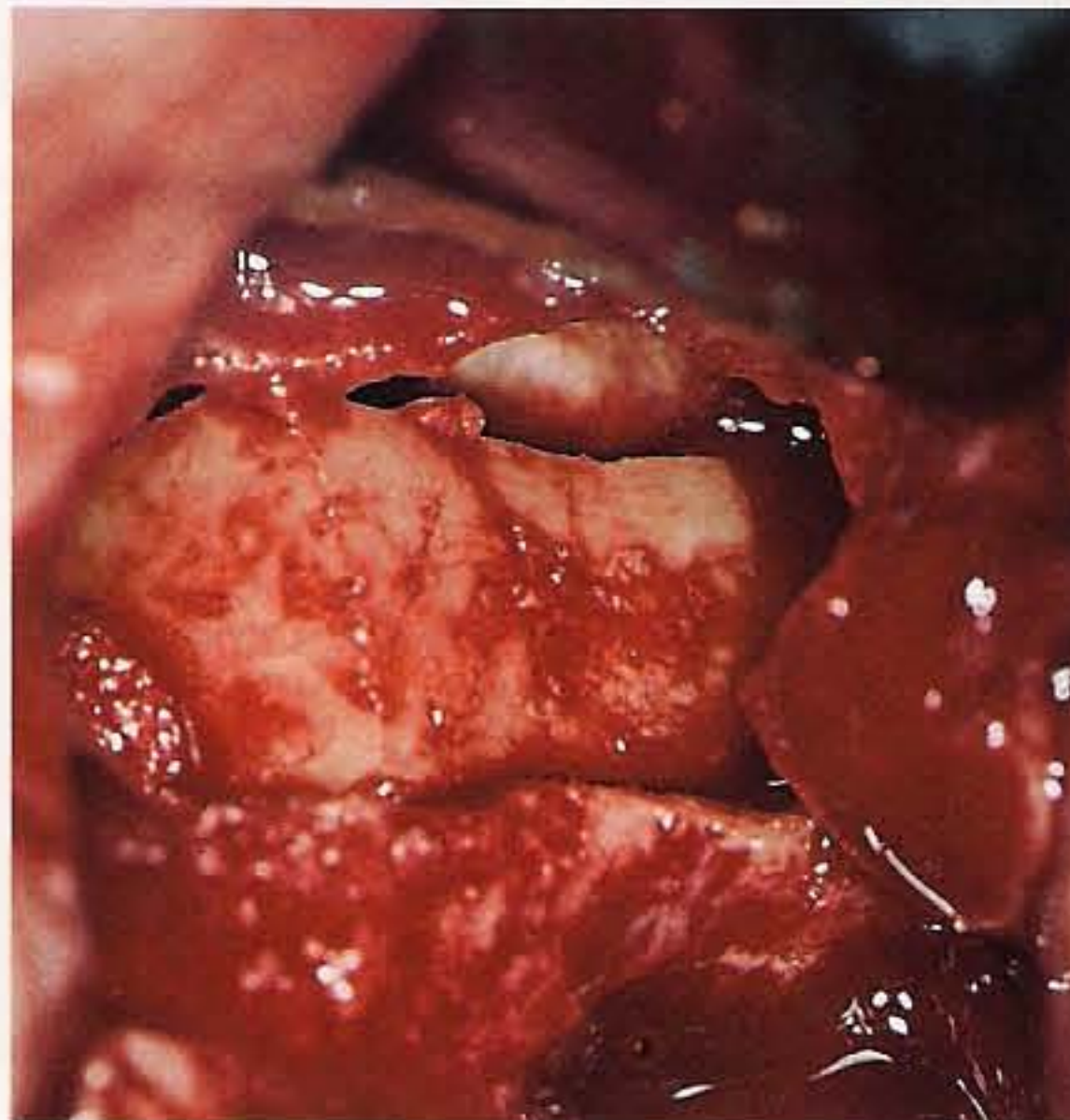


Fig 9-63 (far right) The bone block is stabilized with a plate and screws.



Fig 9-64 Radiographic examination at 6 months. The graft is visible.

Fig 9-65 The plate is removed prior to placement of the implant. Note the perfect healing of the graft.

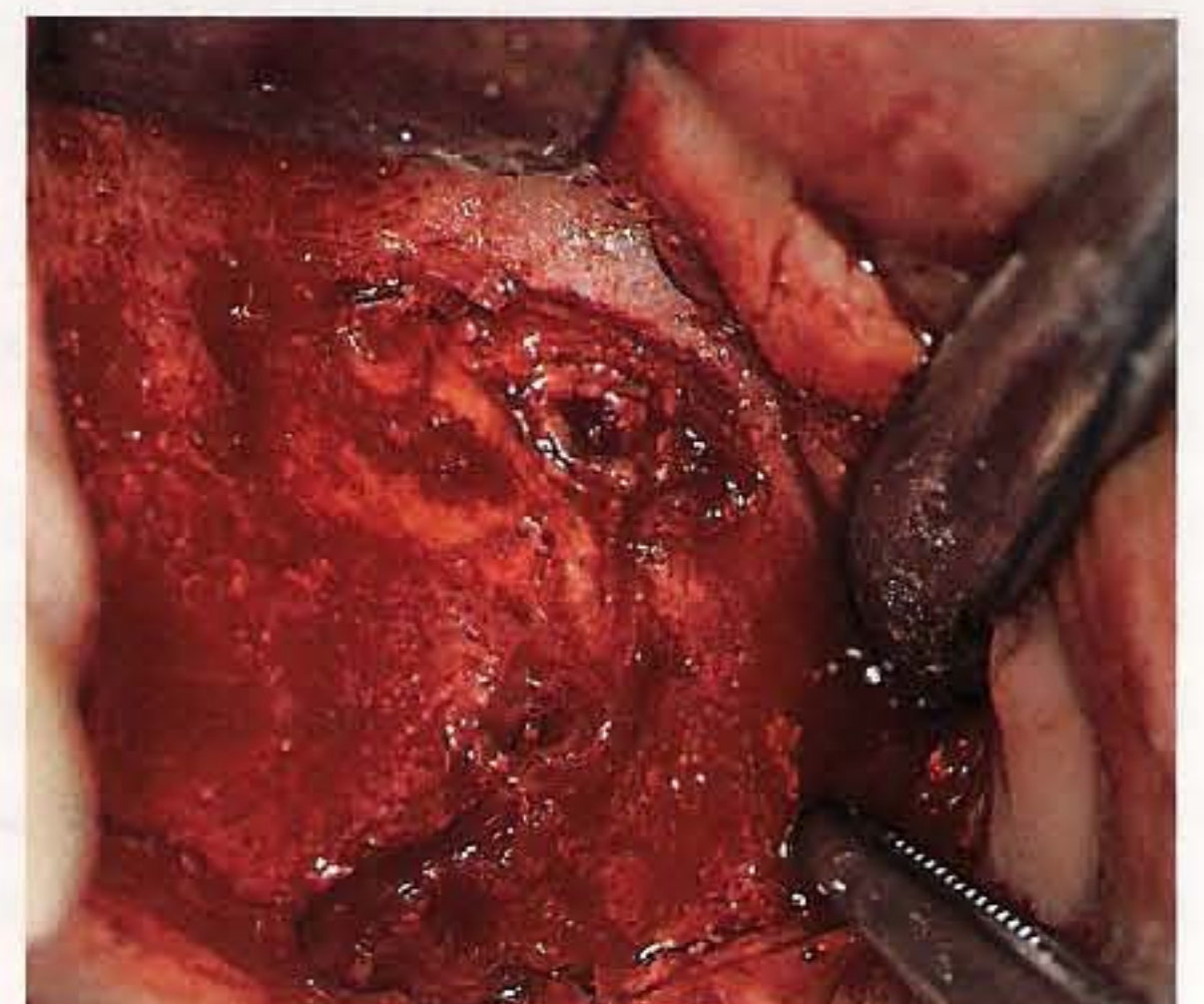




Fig 9-66 A panoramic radiograph is made to confirm the position of the three implants.

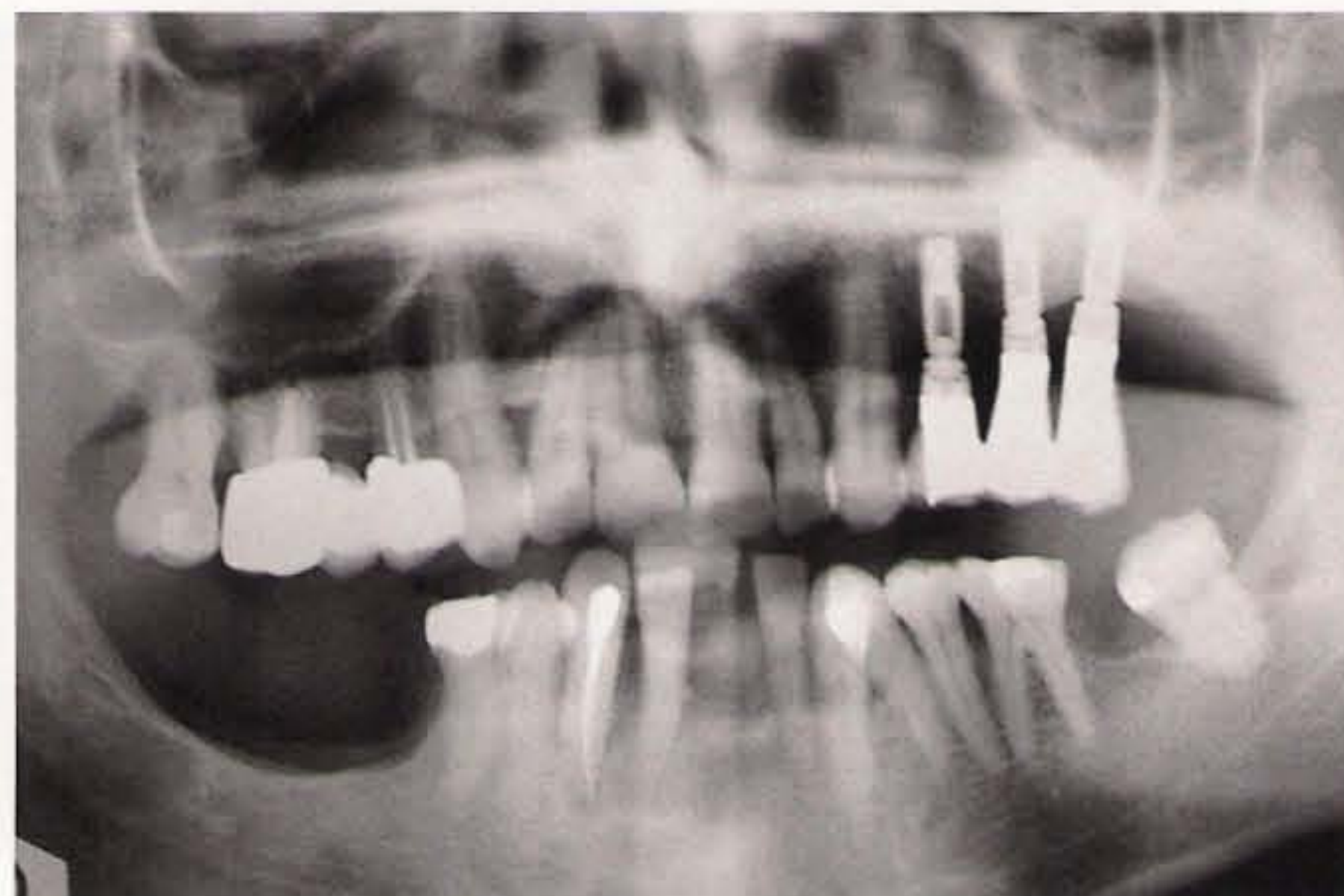


Fig 9-67 A panoramic radiograph is used to evaluate the completed prosthesis.

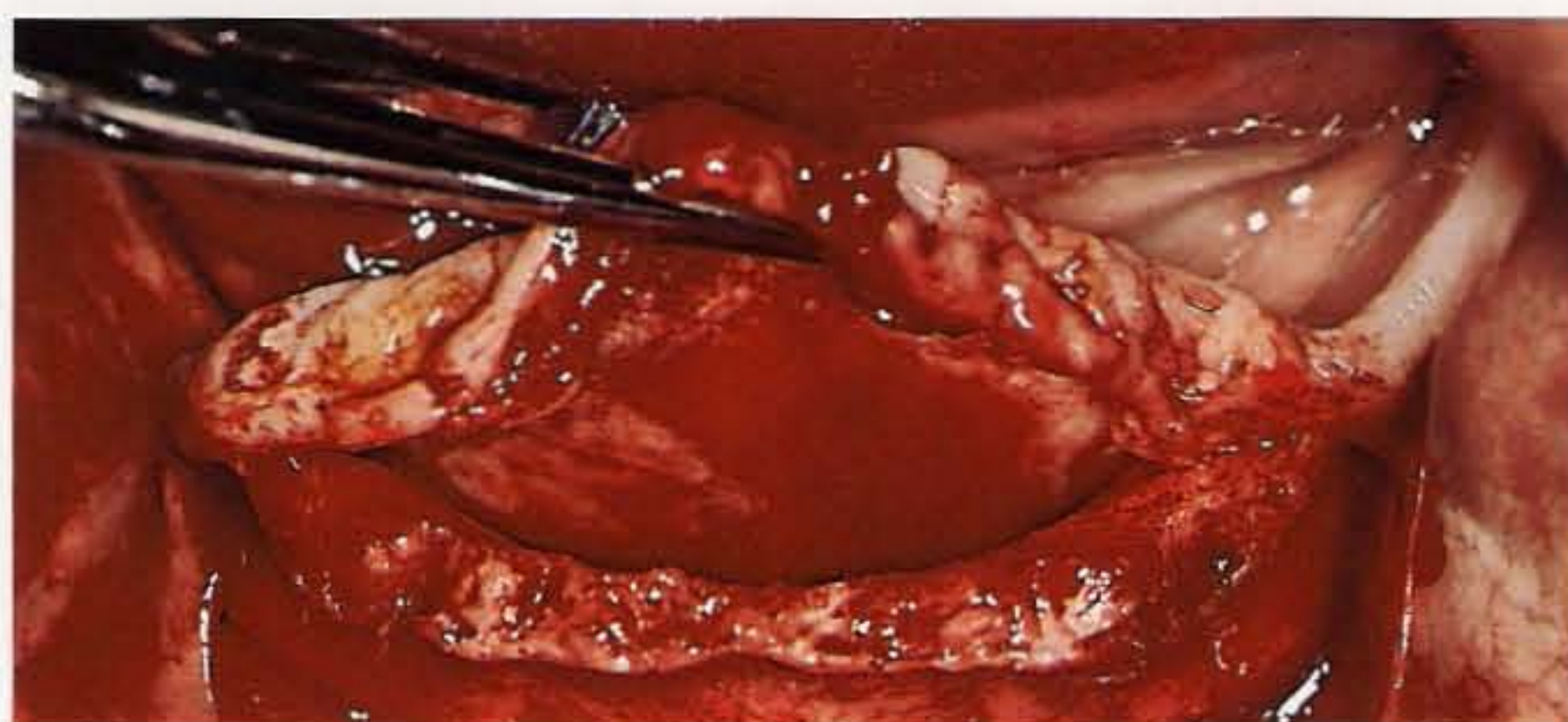


Fig 9-68 The surgical flap reveals the resorbed alveolar crest.



Fig 9-69 Preparations have been created for implants; the 2-mm drill has created bone fenestrations.



Fig 9-70 The implants are positioned with optimal primary stability in the residual bone.

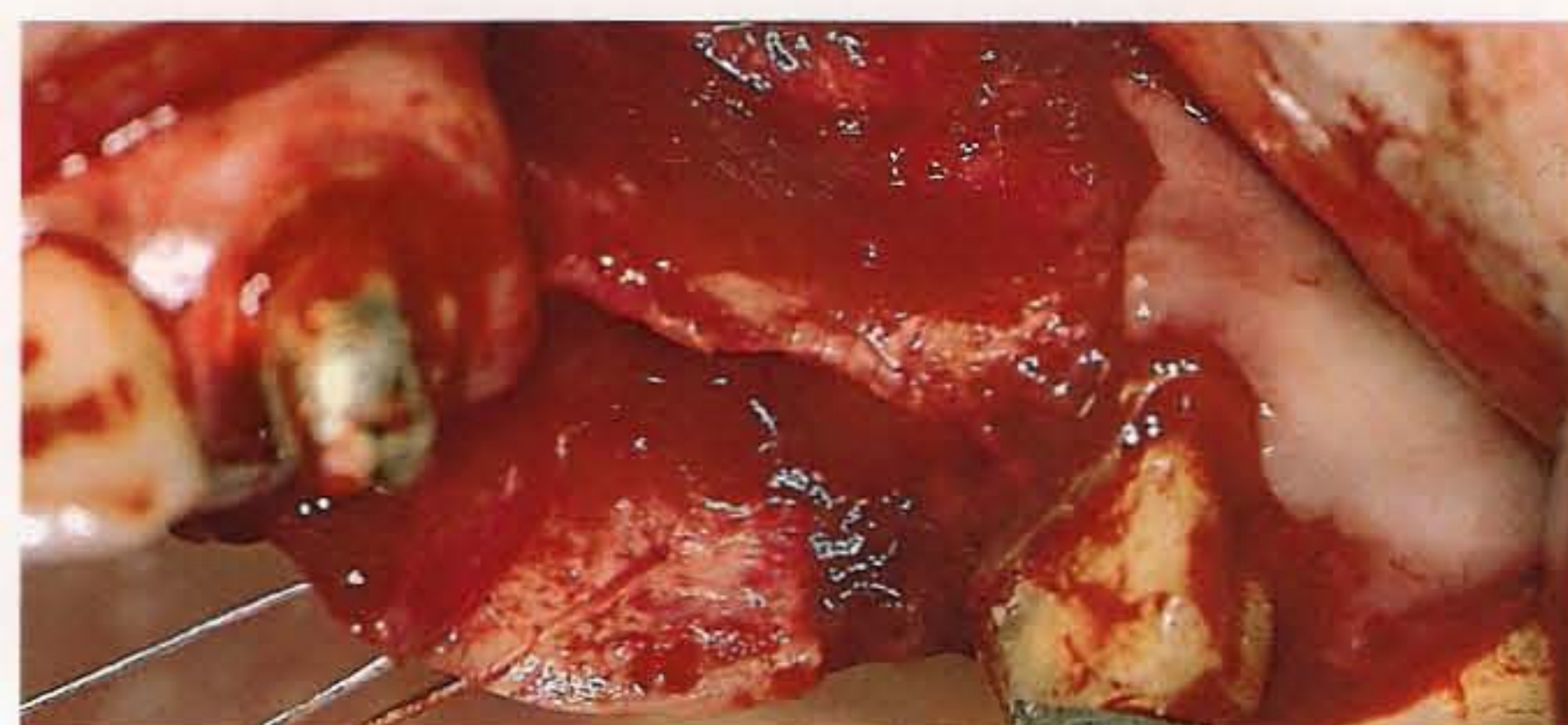


Fig 9-71 The thin alveolar crest (about 1.5 mm) is insufficient for implant placement.

Reconstruction of the alveolar crest

The minimum bone dimensions required for the placement of implants are 8 mm in terms of height and 4 mm in terms of thickness.⁹⁶ Postextraction bone resorption on the horizontal plane can create morphologic alterations of the alveolar crests severe enough to render implant placement difficult. In implant surgery, these conditions can be subdivided into:

- Conditions in which the thickness of the alveolar bone is reduced: Fenestrations or buccal dehiscences occur around the implants (Figs 9-68 to 9-70).
- Conditions in which the thickness of the crest is reduced to such an extent that positioning of the implants is impossible (Fig 9-71).



Fig 9-72 A single tooth is missing after trauma in the region of the maxillary left central incisor.

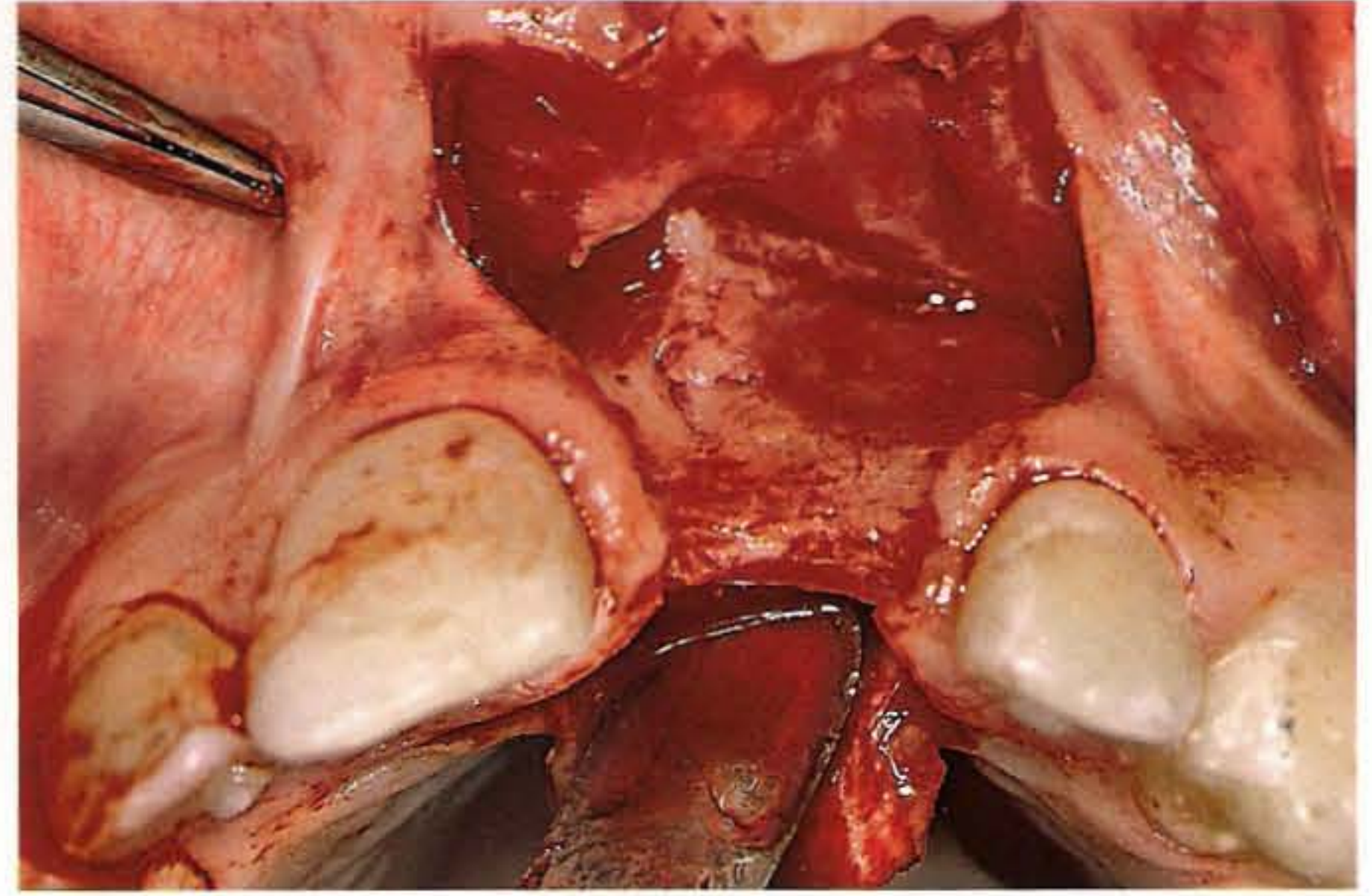


Fig 9-73 Surgical access, created with a trapezoidal full-thickness flap, reveals a resorbed osseous crest that is inadequate for placement of an implant.

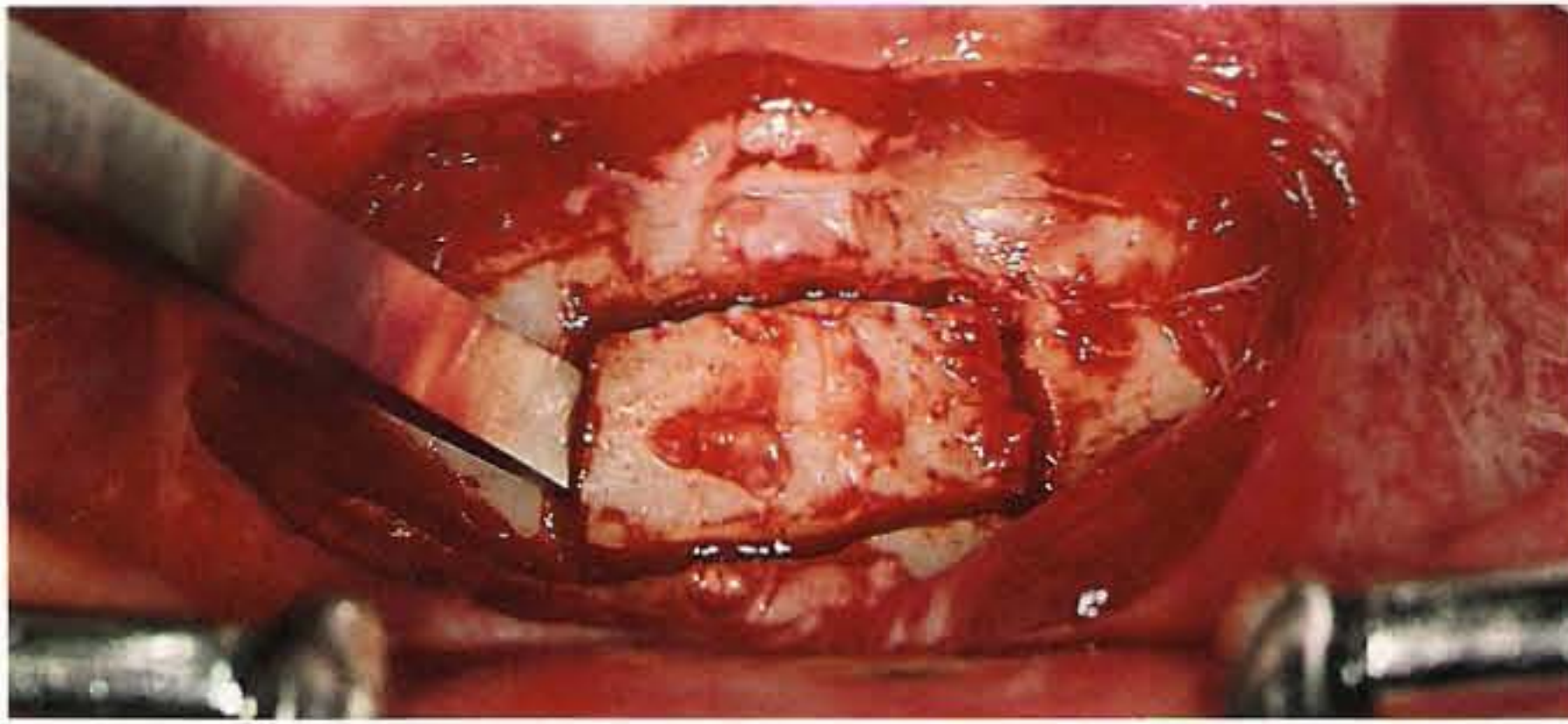


Fig 9-74 A bone block is harvested from the mental symphysis; the block is detached with a scalpel.

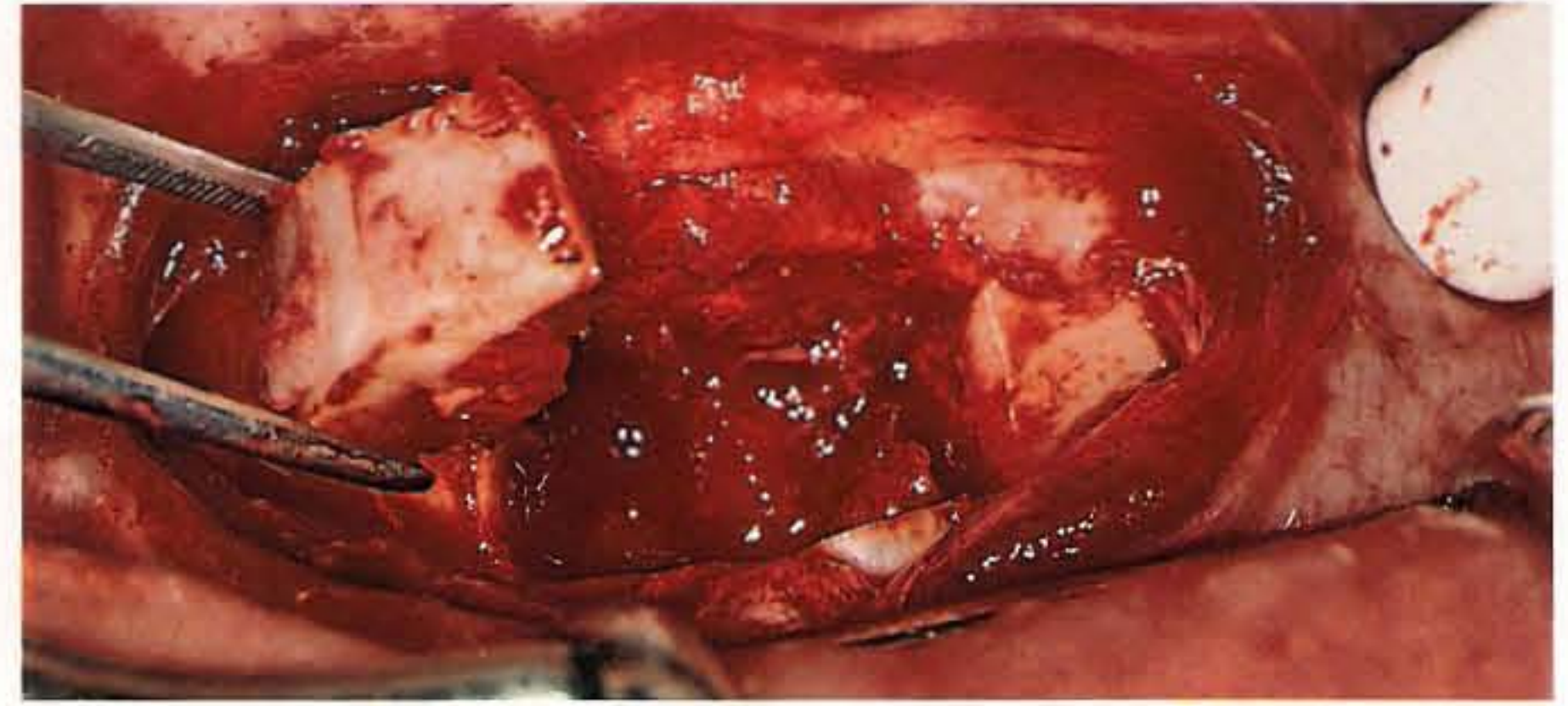


Fig 9-75 The block is removed after it is detached.

In the first category, the surgical techniques allow a thickening of the crest simultaneously with the positioning of the implants. To achieve this, it is possible to use onlay grafts, regenerative techniques with a barrier membrane, or expansion of the crest. All these techniques can be adopted separately or in combination with each other.

In the second group, it is necessary to reconstruct the bone crest before the positioning of the implants.¹⁵⁴

Onlay bone grafting of the alveolar crest

In the onlay technique, after the soft tissues and the periosteum are detached, the graft is directly positioned on the exposed alveolar crest in such a way that the vertical and horizontal dimensions are increased (buccolingual expansion).

In the 1950s and 1960s, Obwegeser¹⁵⁵ introduced the technique of inserting an onlay bone graft on the edentulous alveolar crests to increase the stability of mobile prostheses. The immediate result was optimal; in the long term, however, a

relapse took place because of the marked osseous resorption of the graft after the addition of the prosthetic load. With the advent of osseointegrated implantology, the onlay techniques have been reintroduced with success. Keller and coworkers¹⁵⁶ have used grafts of the patient's own bone positioned as an onlay on the alveolar crest and simultaneous insertion of the implants. Resorption did not occur with grafts that were treated with this procedure.

The bone grafts used are usually composed of blocks of corticospungious bone harvested from intraoral or extraoral sites, depending on the quantity of bone necessary.

In partially edentulous ridges with extensive but localized bone resorption, the surgical technique with a crestal or buccal onlay graft can be used (Figs 9-72 to 9-83); the ascending ramus of the mandible or the mental symphysis can be used as a donor site. The success rate of the implants is 100%, both with bone grafts harvested from the mandibular ramus¹³⁰ and with block grafts harvested from the mental symphysis.¹⁵⁷



Fig 9-76 The graft is remodeled and adapted to the crest (saddle graft).

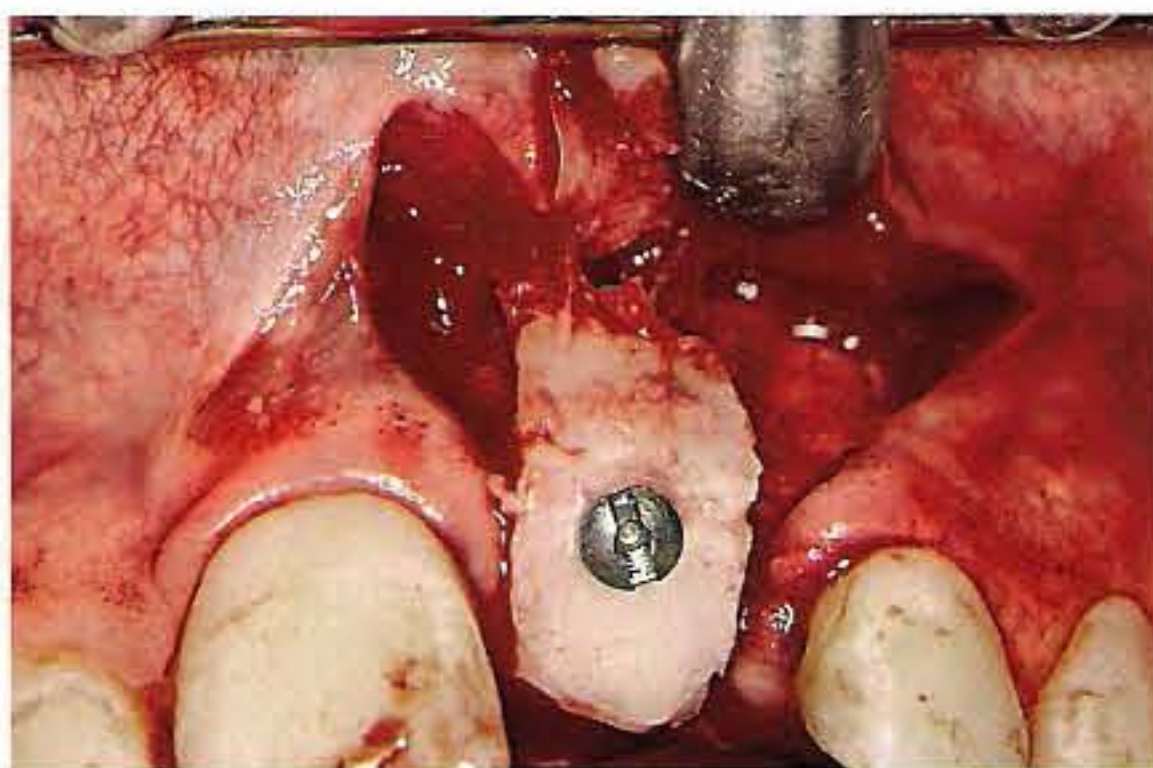


Fig 9-77 The block is rigidly fixed with screws.

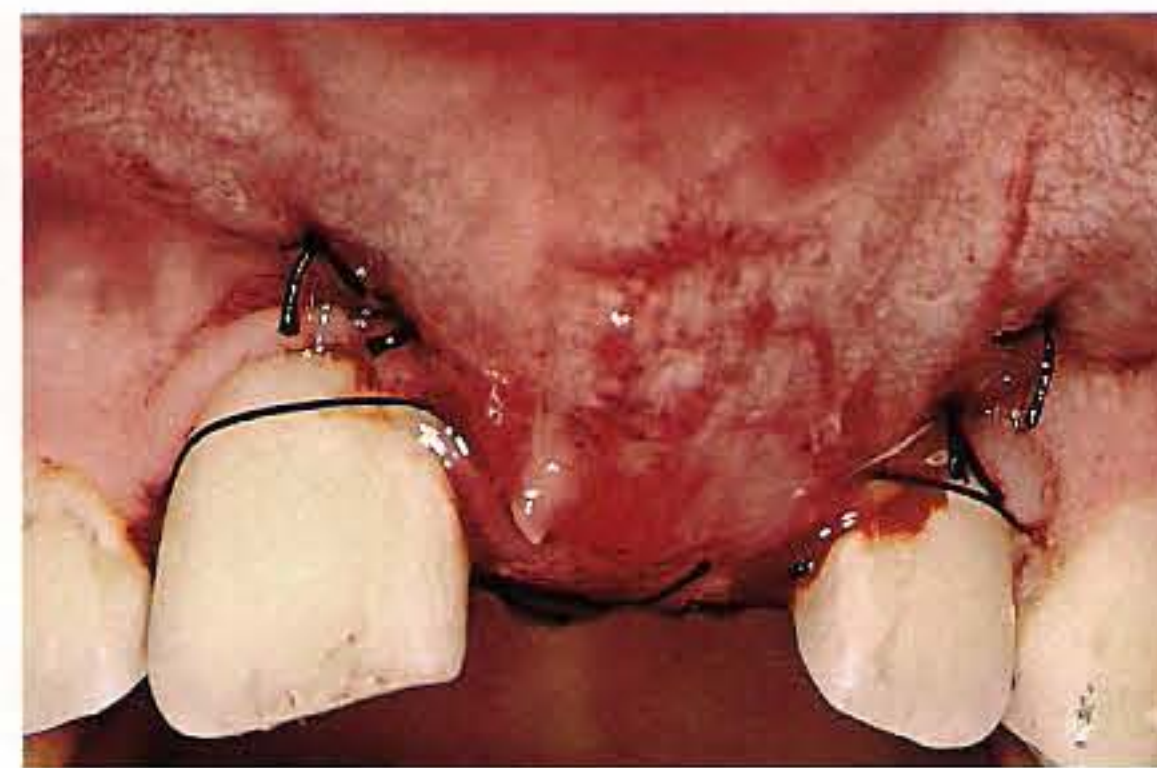


Fig 9-78 The soft tissues are sutured.

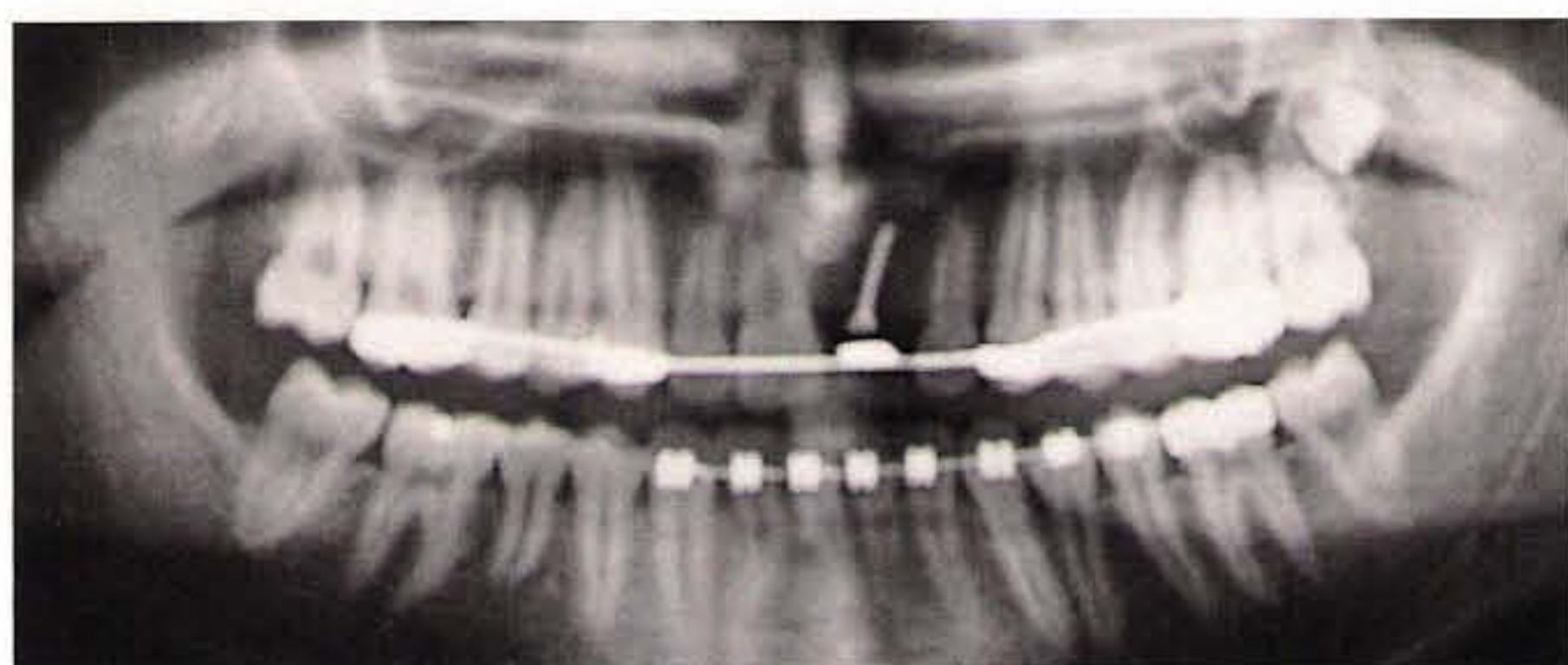


Fig 9-79 The panoramic radiograph reveals healing of the graft after 6 months.



Fig 9-80 There is considerable resorption of the graft after 6 months of healing.



Fig 9-81 The graft is extremely resorbed.

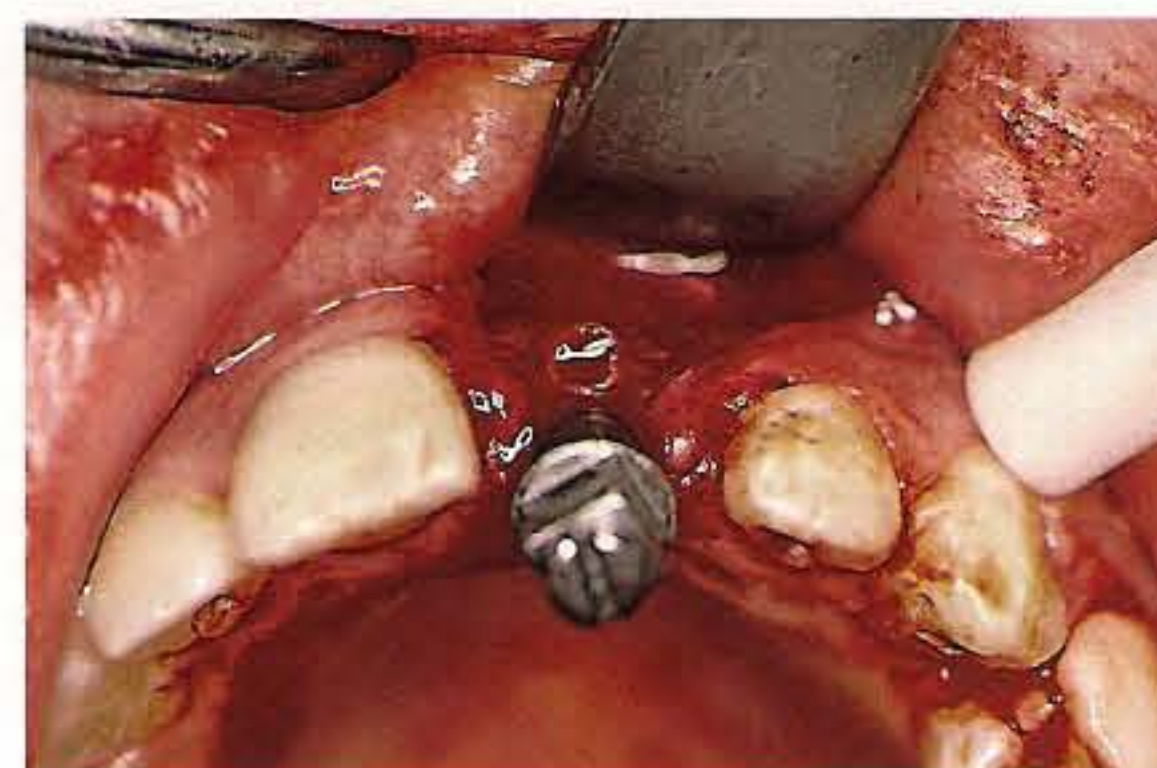


Fig 9-82 A Brånemark implant (Nobel Biocare) is placed in the correct position.

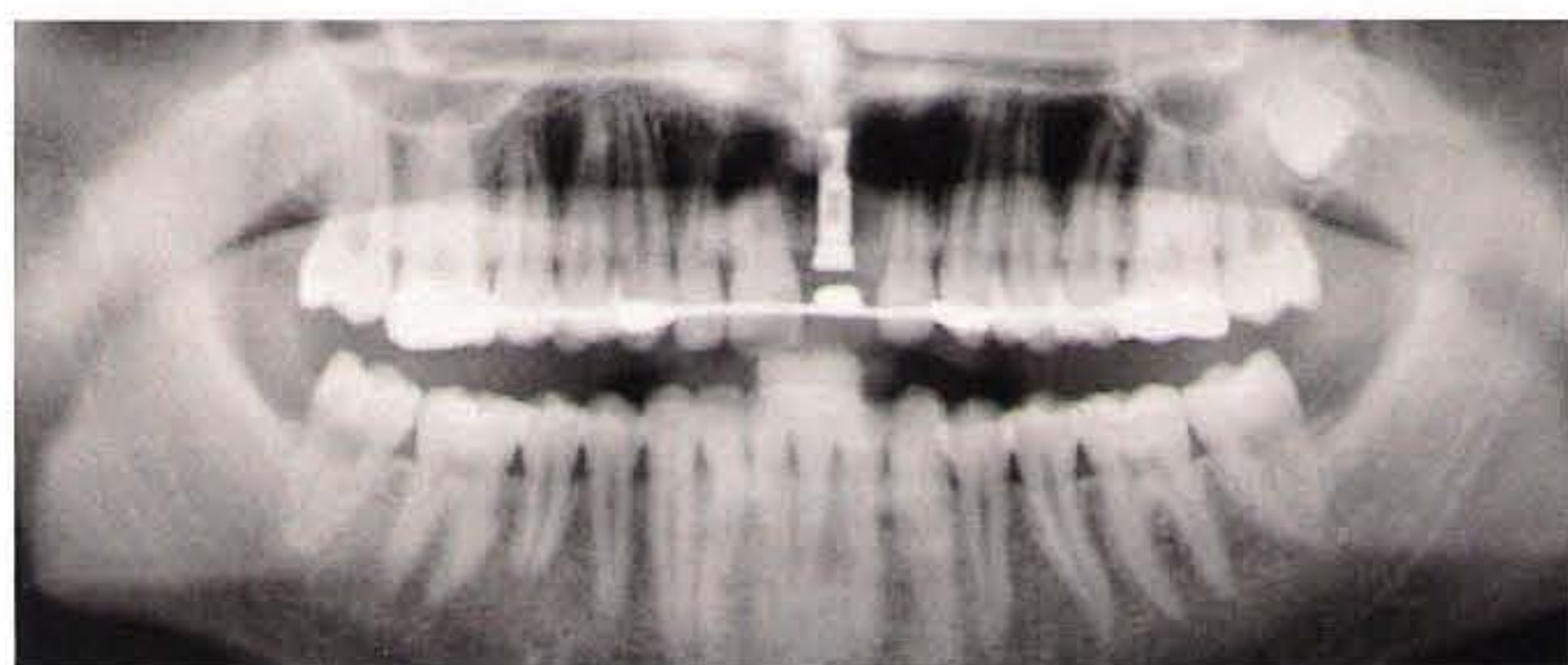


Fig 9-83 A panoramic radiograph is used for assessment of the implant after 6 months.

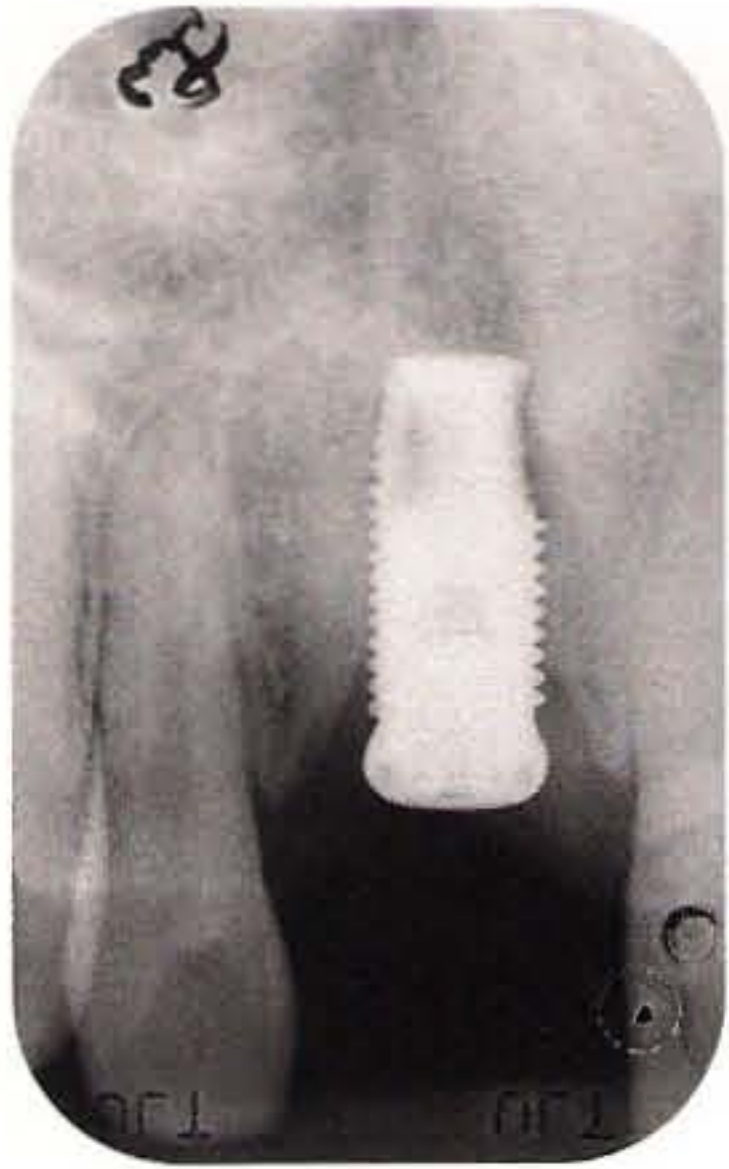


Fig 9-84 An intraoral control radiograph is taken after 6 months.

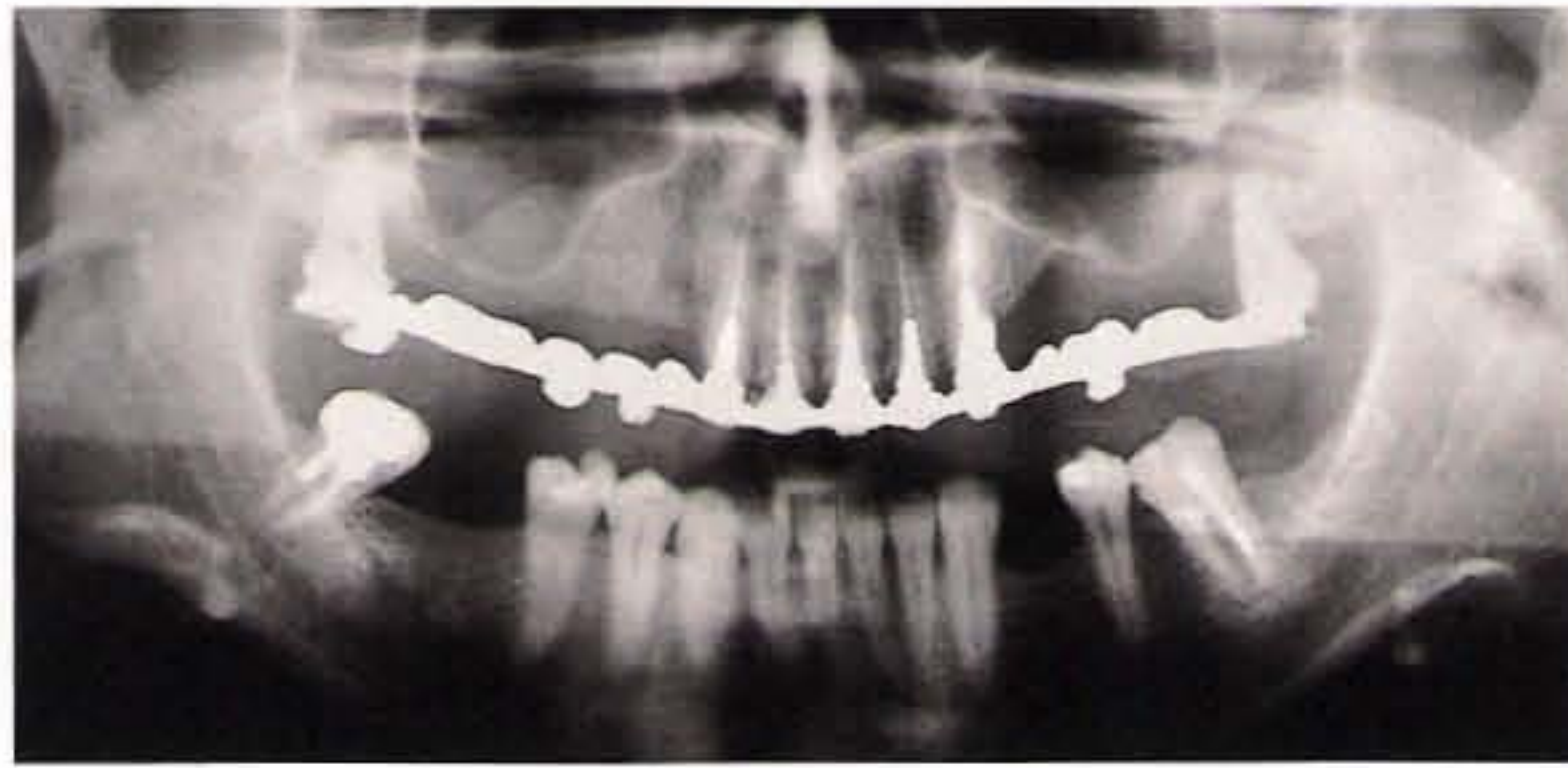


Fig 9-85 Initial panoramic radiograph. The patient has a provisional fixed prosthesis of reinforced resin, ideal for the waiting period until the implant has healed.



Fig 9-86 A segment of the maxillary right quadrant is edentulous.



Fig 9-87 The osseous crest is thin but of sufficient height.

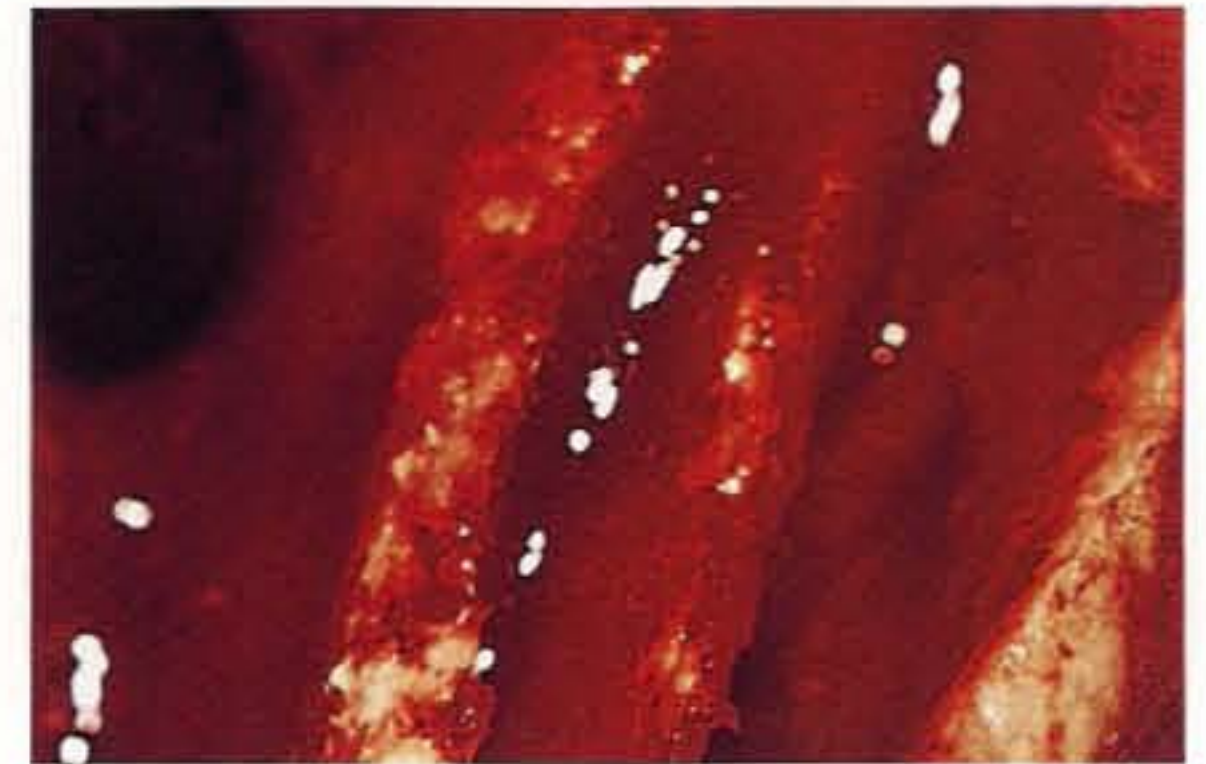


Fig 9-88 A greenstick fracture is created with surgical scalpels.



Fig 9-89 The cortical bone is opened after apical preparation with a drill.

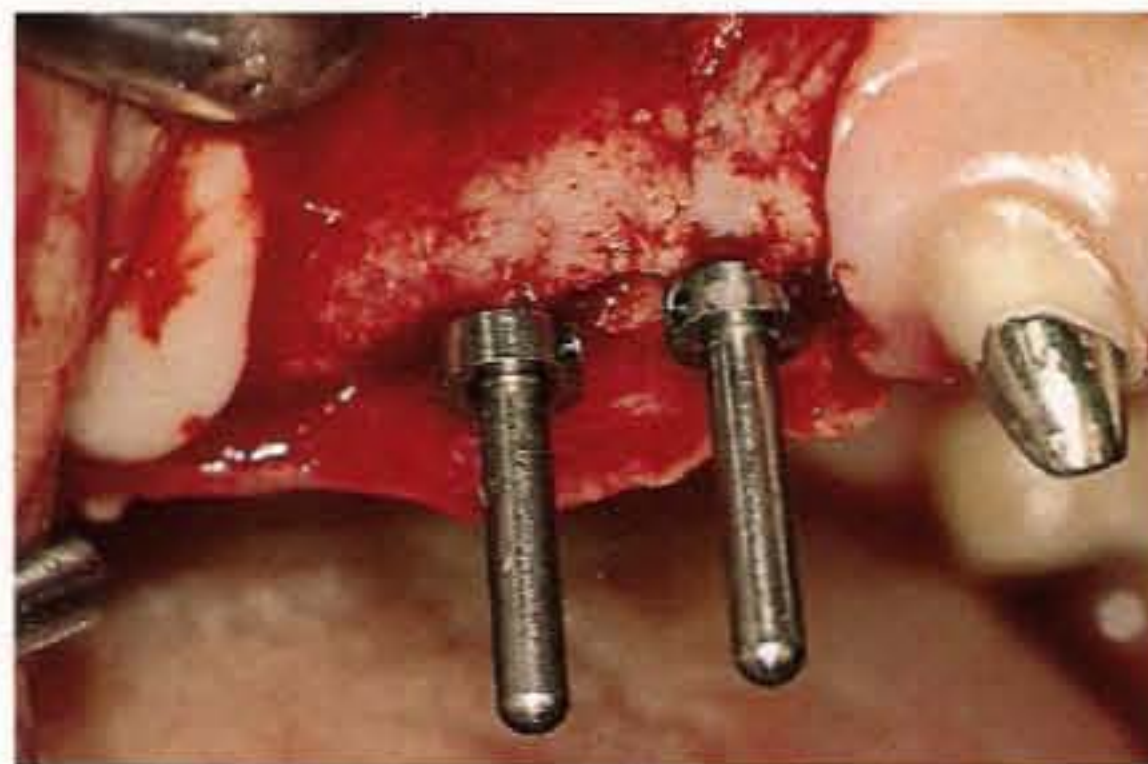


Fig 9-90 The parallelism of the posts is confirmed.



Fig 9-91 The implants are placed.

Surgical expansion of the alveolar crest

Surgical expansion of the alveolar crest is necessary when the clinical situation is characterized by a quantity of bone that is reduced horizontally but sufficient in height. In this case, a longitudinal greenstick fracture is made with subsequent separation of the two osseous cortical layers. The depth of the cut must be about 7 to 8 mm. The implants, which must have good primary stability, are placed apical to the fracture in the 4 to 5 mm of residual intact bone. Depending on the space present after the expansion of the two osseous cortices, a membrane is

adapted over the site or the site is filled with the patient's own bone or a donor bone graft. When this technique is carried out near a natural tooth, at least 2 mm of intact bone must be left around that tooth. The membranes must be left in the site for 6 months and must be removed during stage 2 surgery. Various studies have reported encouraging results regarding both the quality of regenerated tissue and the implant success rate¹⁵⁸ (Figs 9-84 to 9-97).

The technique introduced by Scipioni and collaborators,¹⁵⁹ a mini-elevation of the maxillary sinus, can also be used in the zones adjacent to the maxillary sinus as an expansion technique

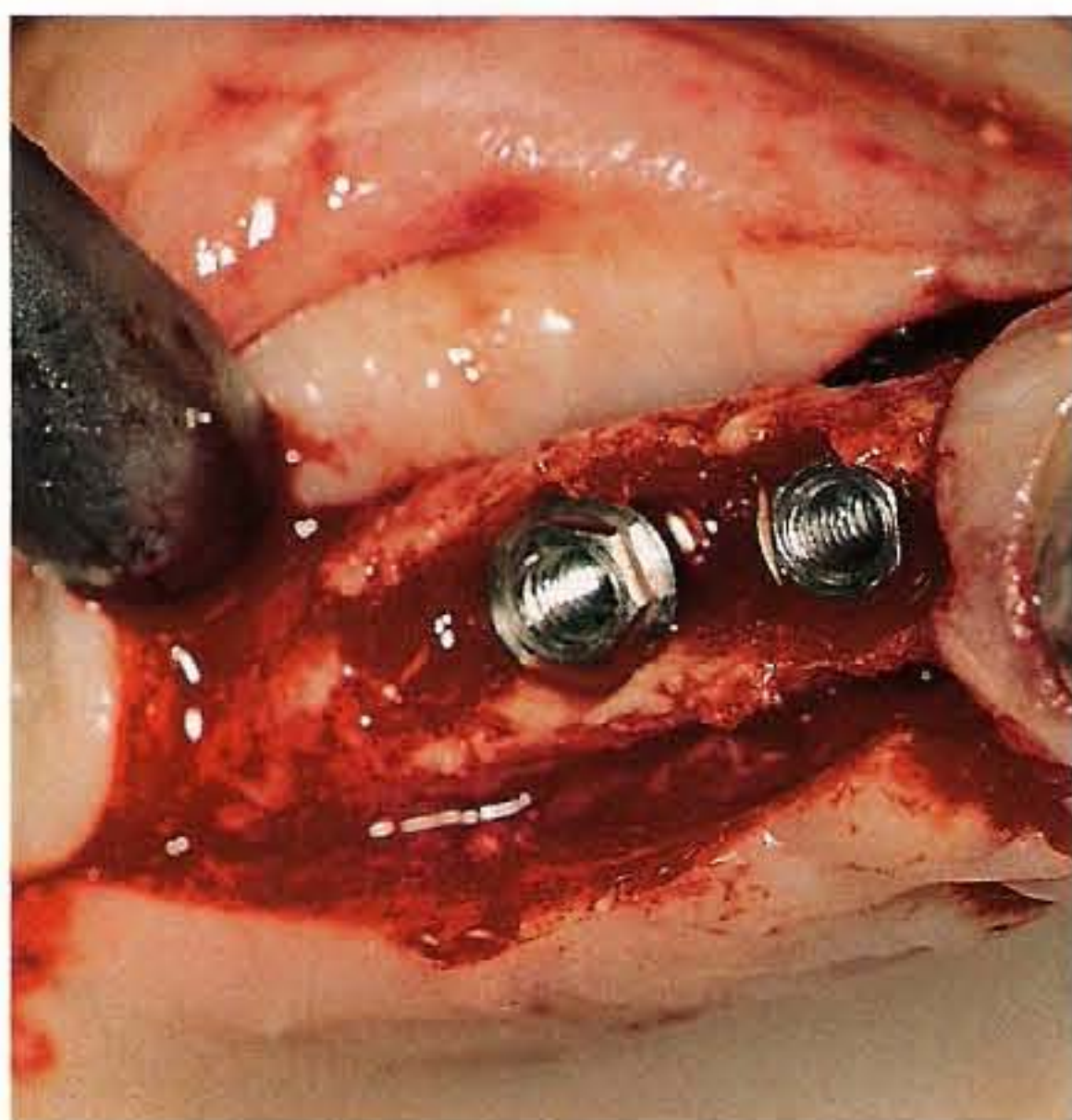


Fig 9-92 (*far left*) After removal of the fixture mount it is possible to view the expansion of the osseous crest and the correct position of the implants.

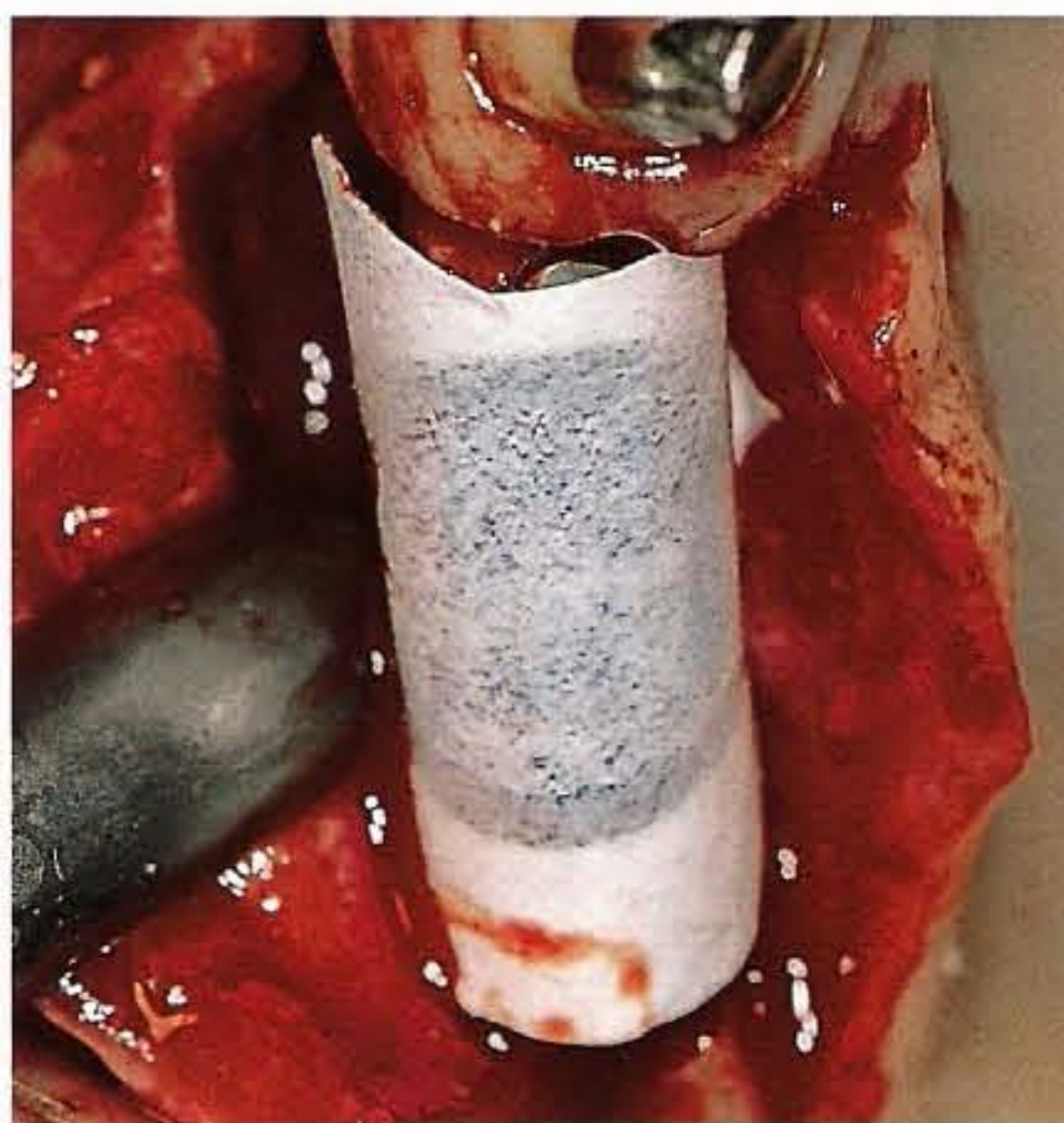


Fig 9-93 (*left*) The membrane is fitted and adapted.

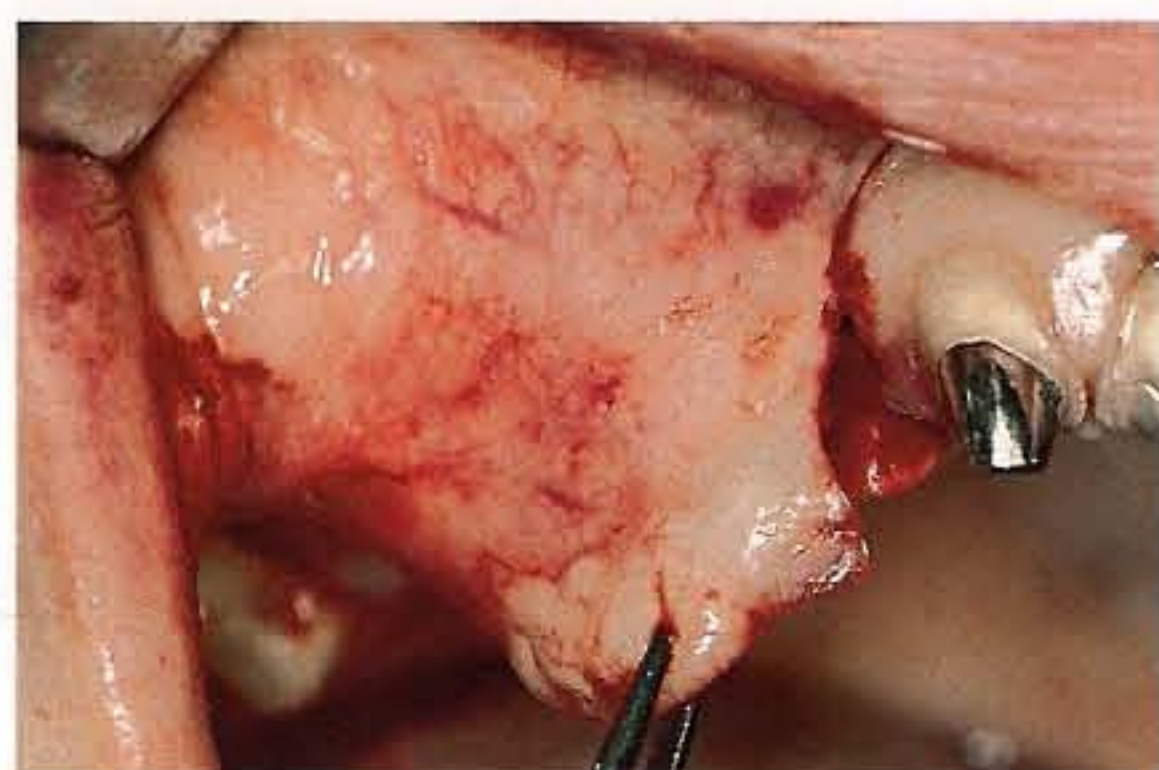


Fig 9-94 The mucoperiosteal flap is mobilized after the periosteal tissues are sectioned.

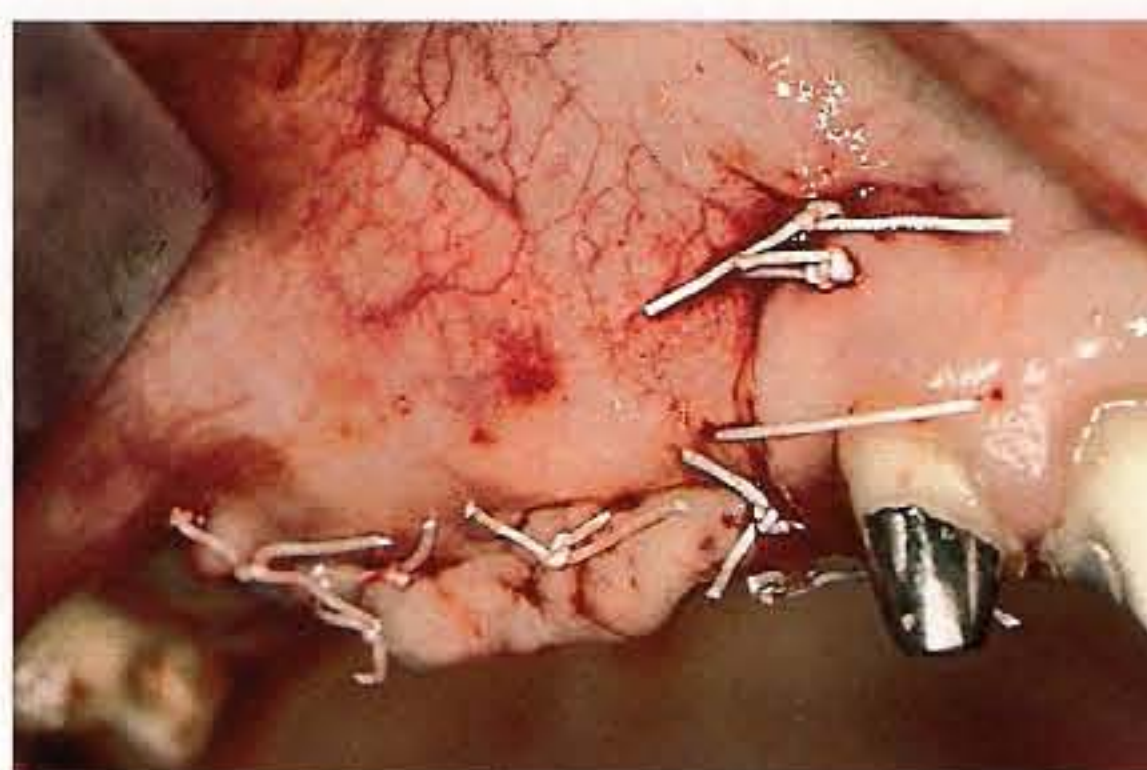


Fig 9-95 Sutures are placed.

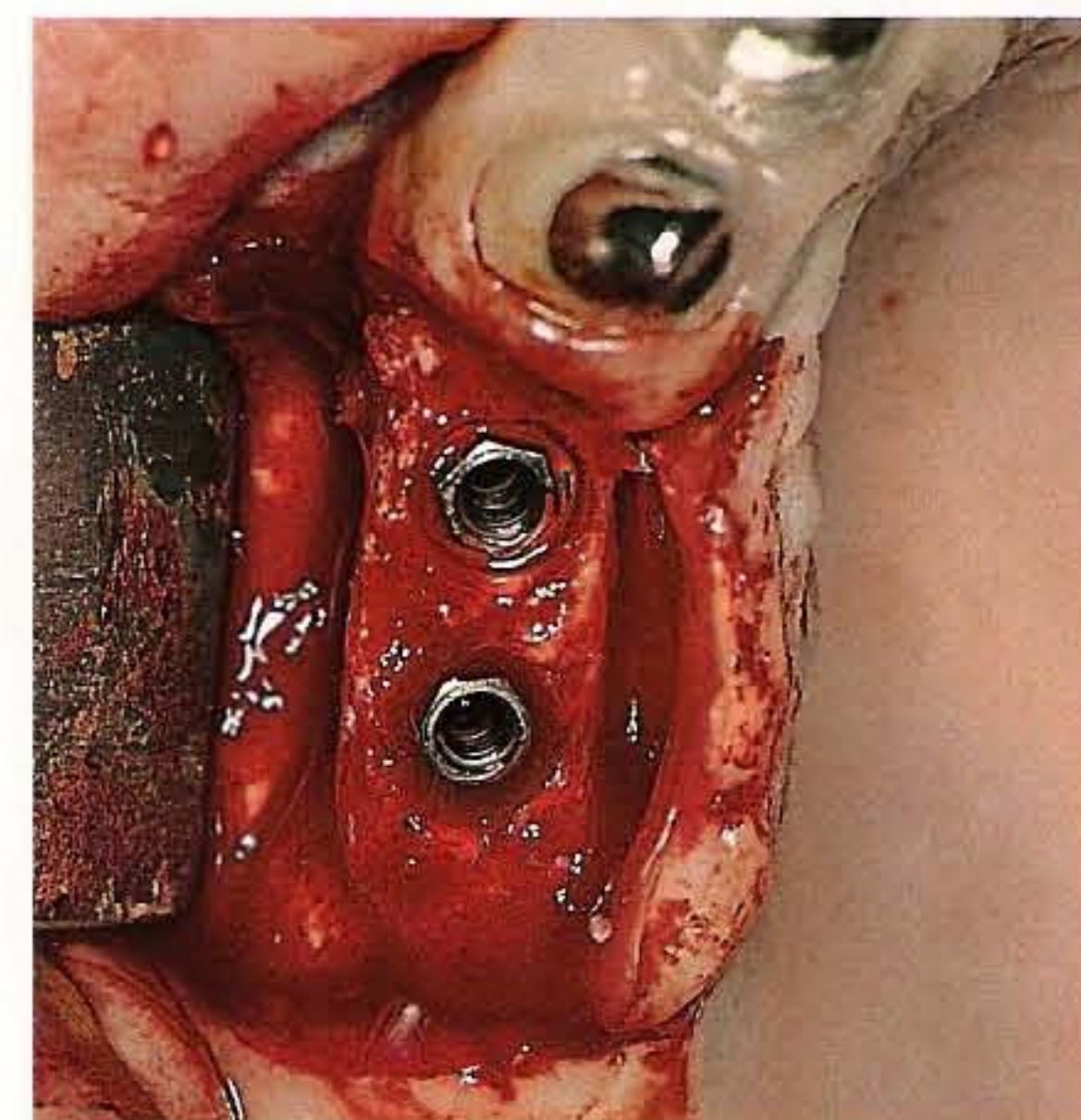


Fig 9-96 Stage 2 implant surgery is performed after 6 months.

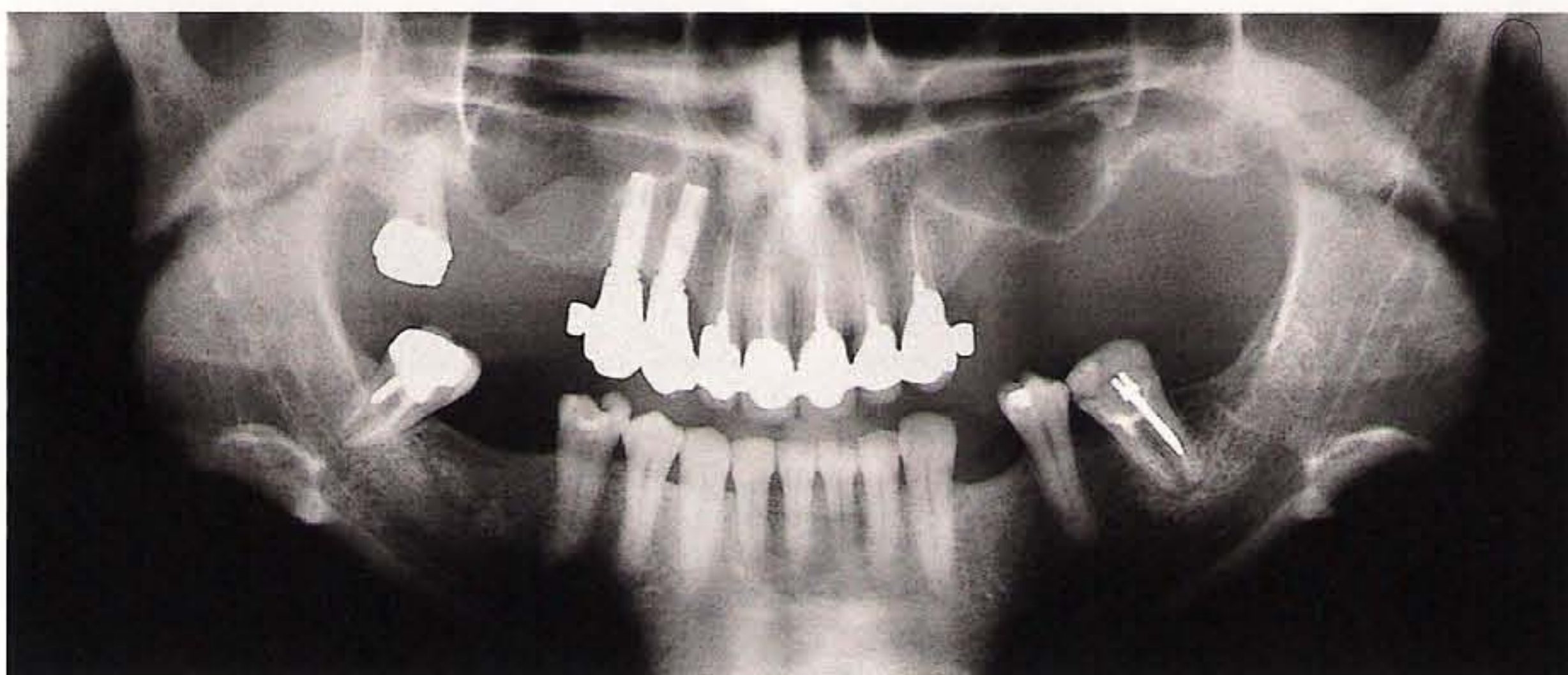


Fig 9-97 Final panoramic radiograph control.

for the crests (edentulous ridge expansion). This technique is particularly advisable in bone types D3 and D4, which are often present in this area, because they are more malleable and modifiable; gaining primary stability is made easier through compaction with the osteotome, because the standard procedure with a drill is more difficult. The use of conical implants simplifies the technique¹⁶⁰ (Figs 9-98 to 9-100).

Vertical augmentation of the bone crest with distraction osteogenesis

Ilizarov and colleagues¹⁶¹ described and recommended the distraction osteogenesis technique in orthopedic surgery to increase the length of the limbs. In 1973, Snyder and collaborators¹⁶² used a surgical method (distractor) to lengthen the body of the mandible of a dog. This new technique was then adopted by Costantino et al¹⁶³ and McCarthy et al¹⁶⁴ in



Fig 9-98 Intraoral radiograph of a patient with an intercalated space restored with a fixed reinforced-resin provisional prosthesis. The vertical osseous dimension is sufficient, but the alveolar crest is very thin.

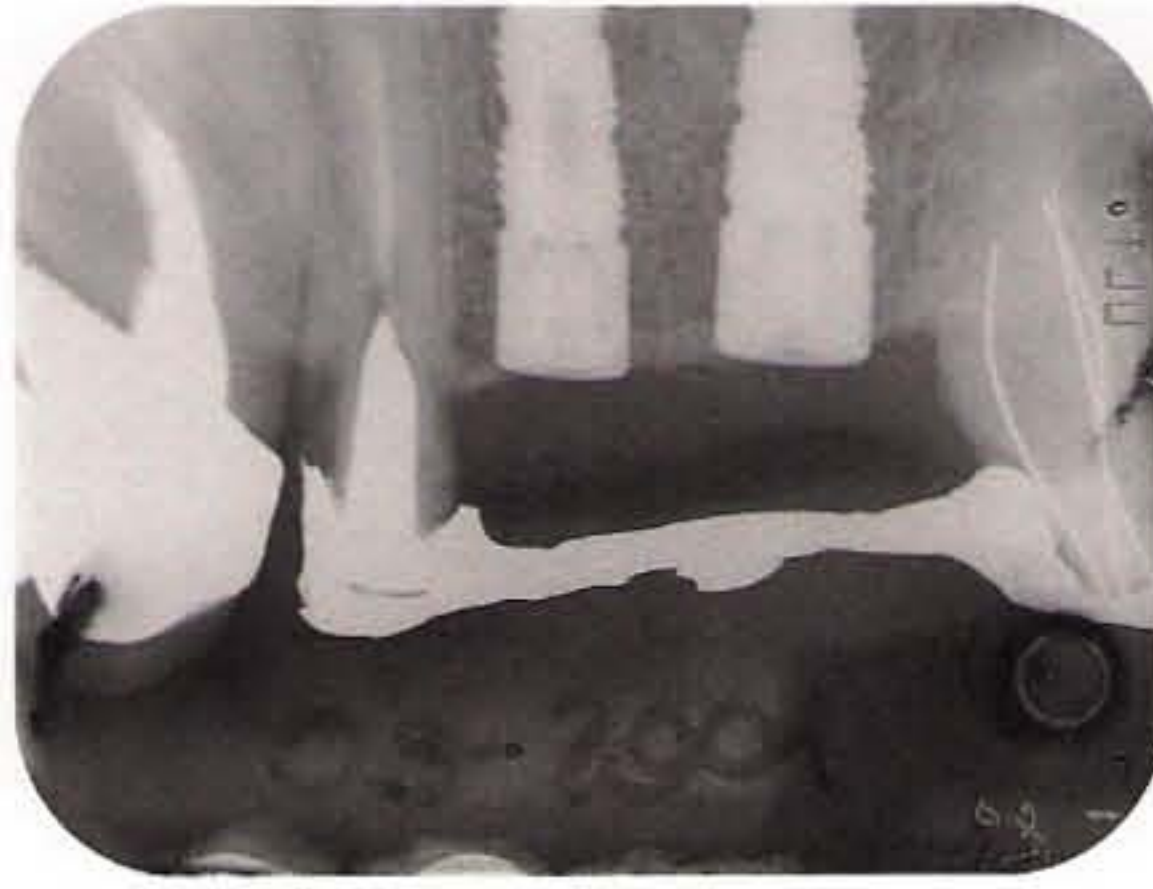


Fig 9-99 Postsurgical radiograph taken after the installation of two conical implants using the edentulous ridge expansion technique.

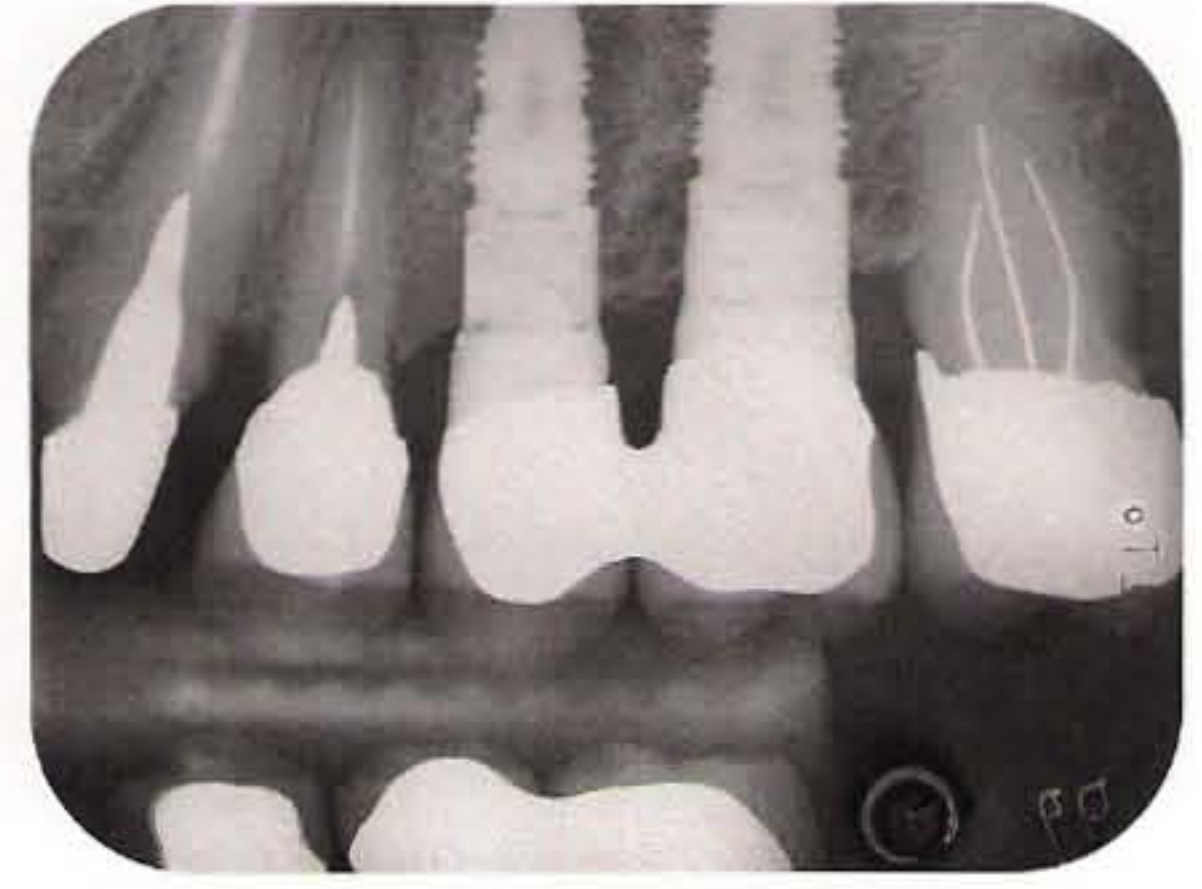


Fig 9-100 Control radiograph taken after loading of the prosthesis.



Fig 9-101 The distal crest in the mandibular right quadrant is edentulous. (Figs 9-101 to 9-113 courtesy of Dr Giorgio Pedretti.)

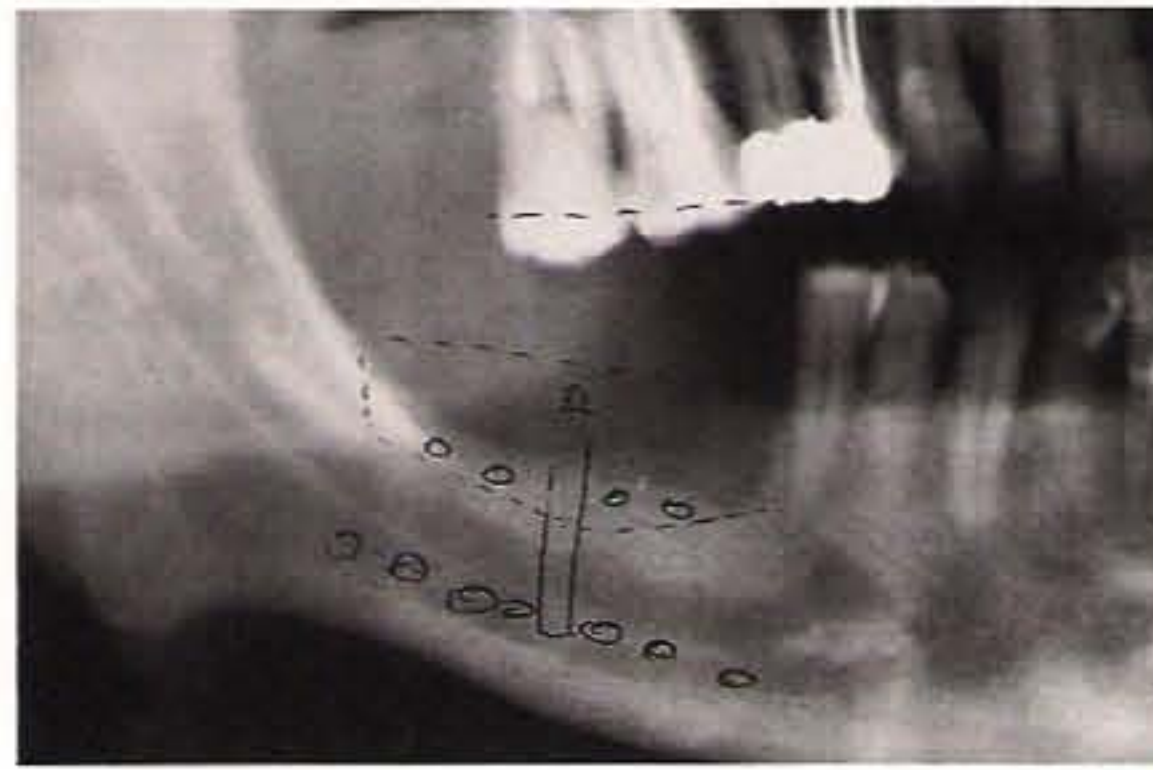


Fig 9-102 The initial panoramic radiograph shows the lack of bone in the edentulous crest.

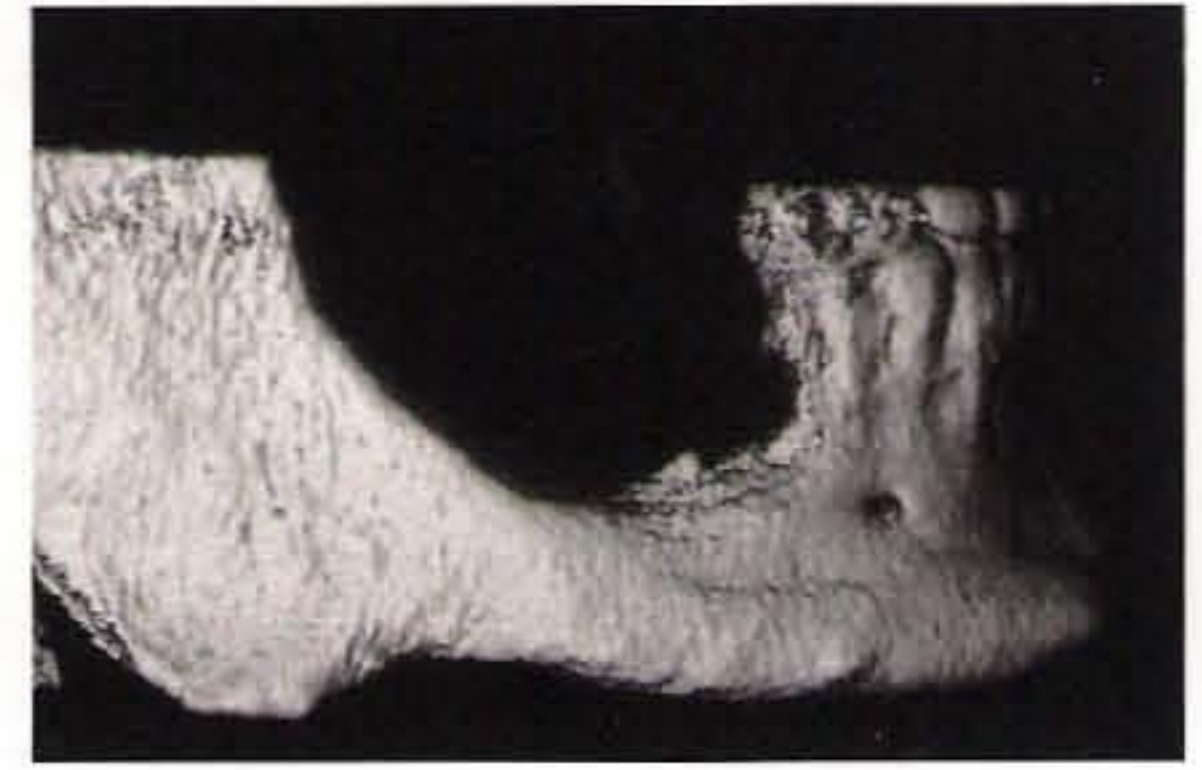


Fig 9-103 Initial three-dimensional CT scan.



Fig 9-104 Surgical access is created to expose the alveolar crest.



Fig 9-105 Osteotomy of the crest is performed.

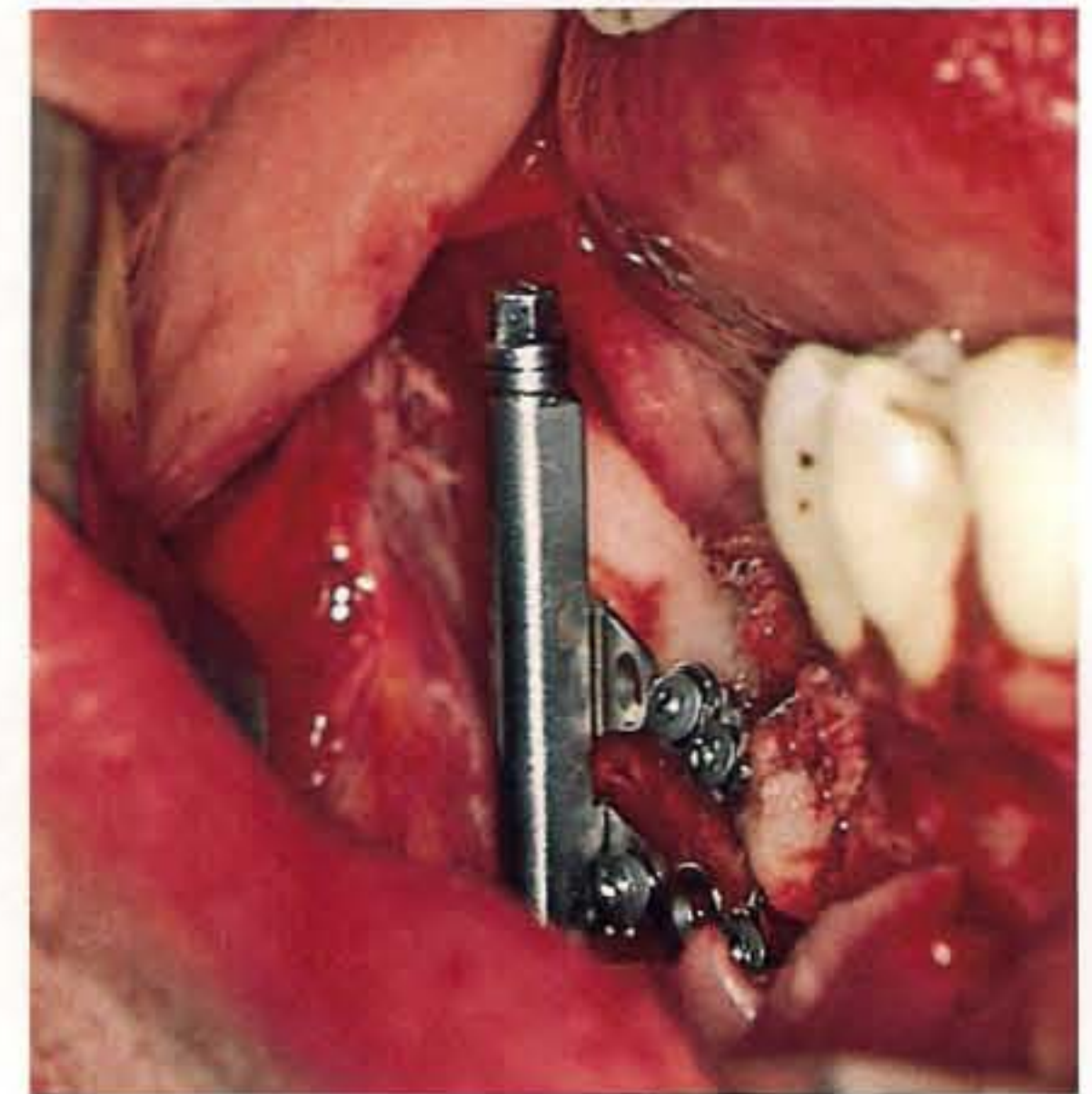


Fig 9-106 The distractor is positioned (Martin-type 1.5).

orthognathic surgery for treatment of an aplastic mandible with very good results.

Chin and Toth,¹⁶⁵ and later Gaggl et al¹⁶⁶ and Watzek et al,¹⁶⁷ obtained vertical growth in the edentulous alveolar crest by using an intraoral distractor and the principles of distraction osteogenesis. The increase in osseous height can reach up to 10

mm and allows positioning of implants that engages both the bone obtained by means of distraction and the basal bone. It has been shown both in animals^{168,169} and in humans¹⁷⁰ that the gap created between distracted bone fragments ossifies completely and that the bone tissue obtained can then receive implants (Figs 9-101 to 9-113).

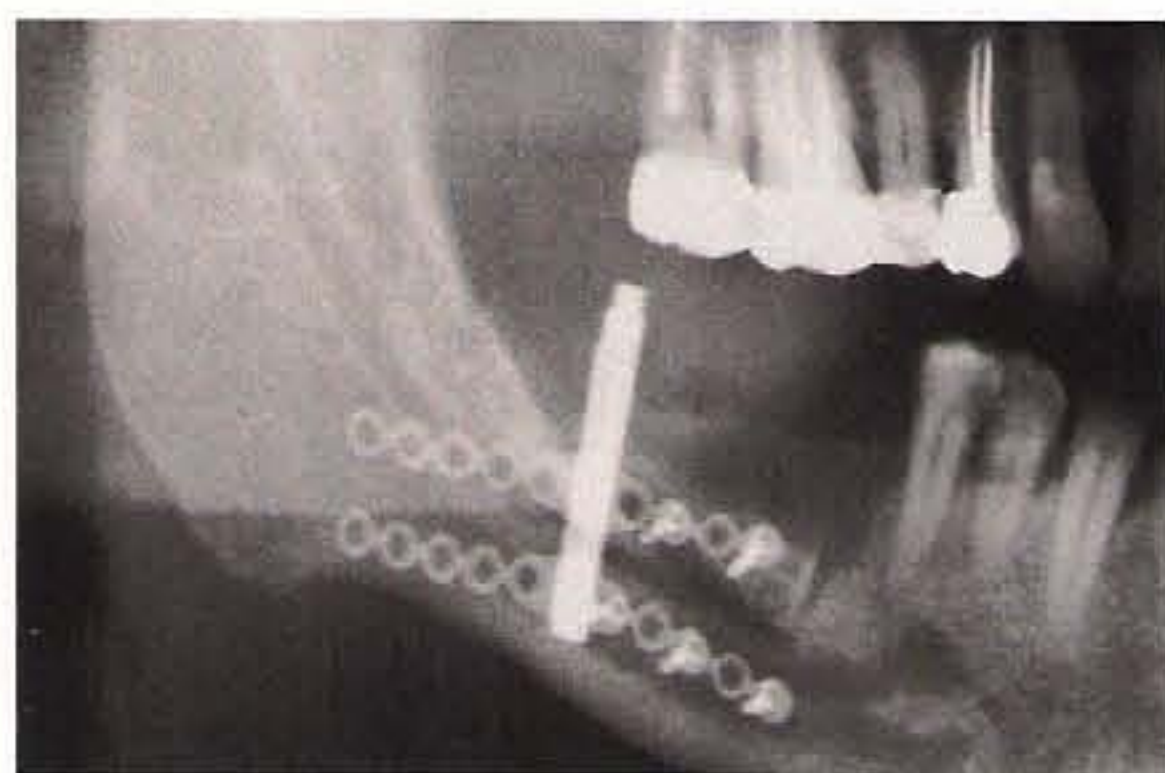


Fig 9-107 A panoramic radiograph is taken after the procedure, to confirm the correct positioning of the distractor.

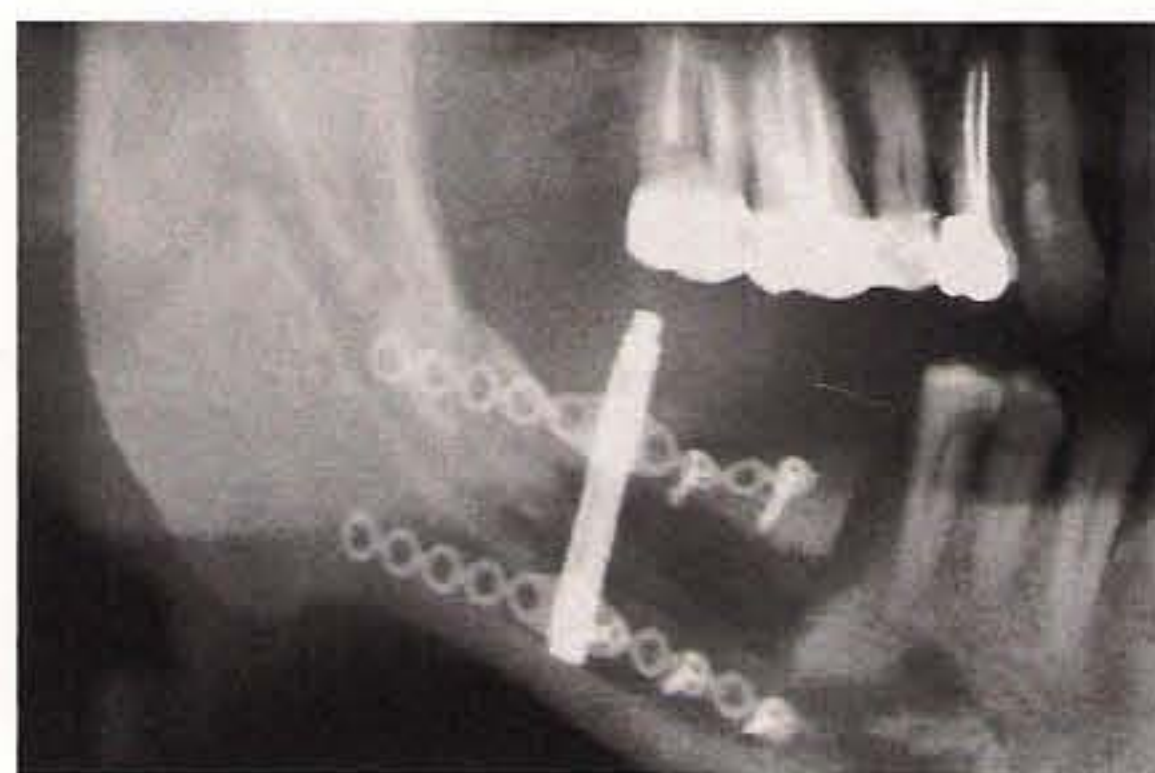


Fig 9-108 A panoramic radiograph is taken at the completion of the distraction to assess the space created by the osseous distraction and the recovered vertical dimension of the alveolar crest.

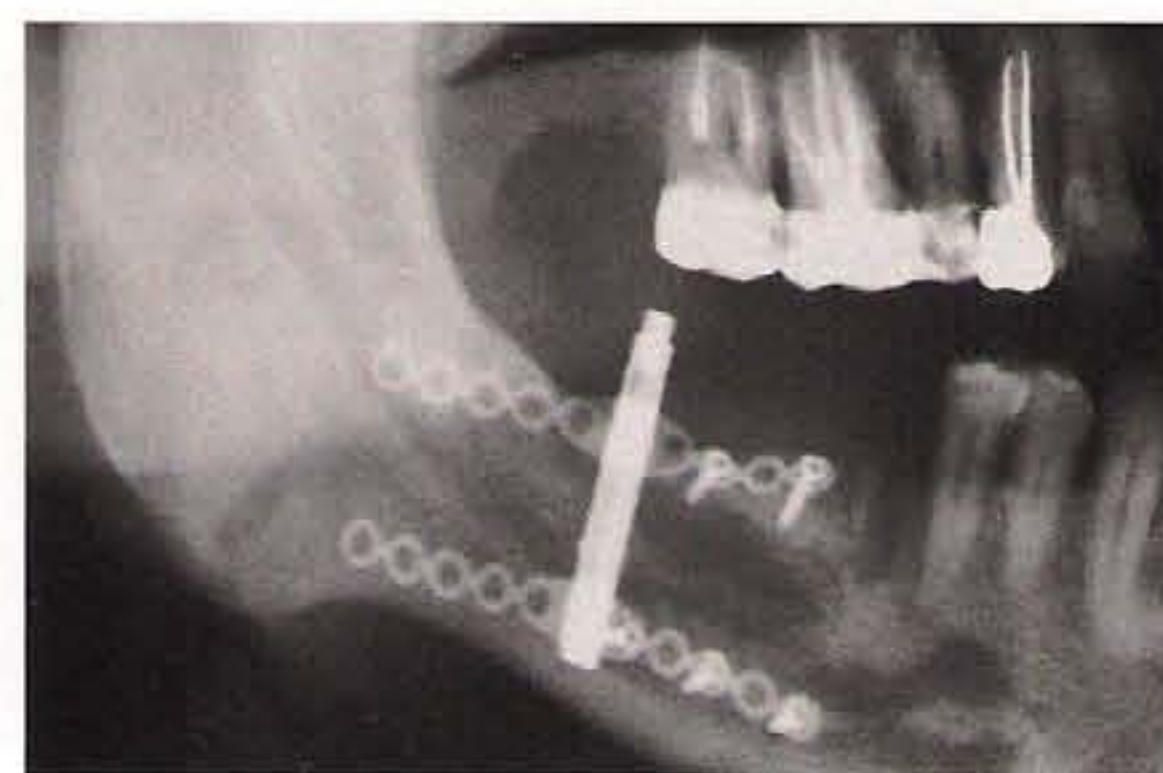


Fig 9-109 A panoramic radiograph taken 3 months after distraction reveals the mineralization of the distracted bone.

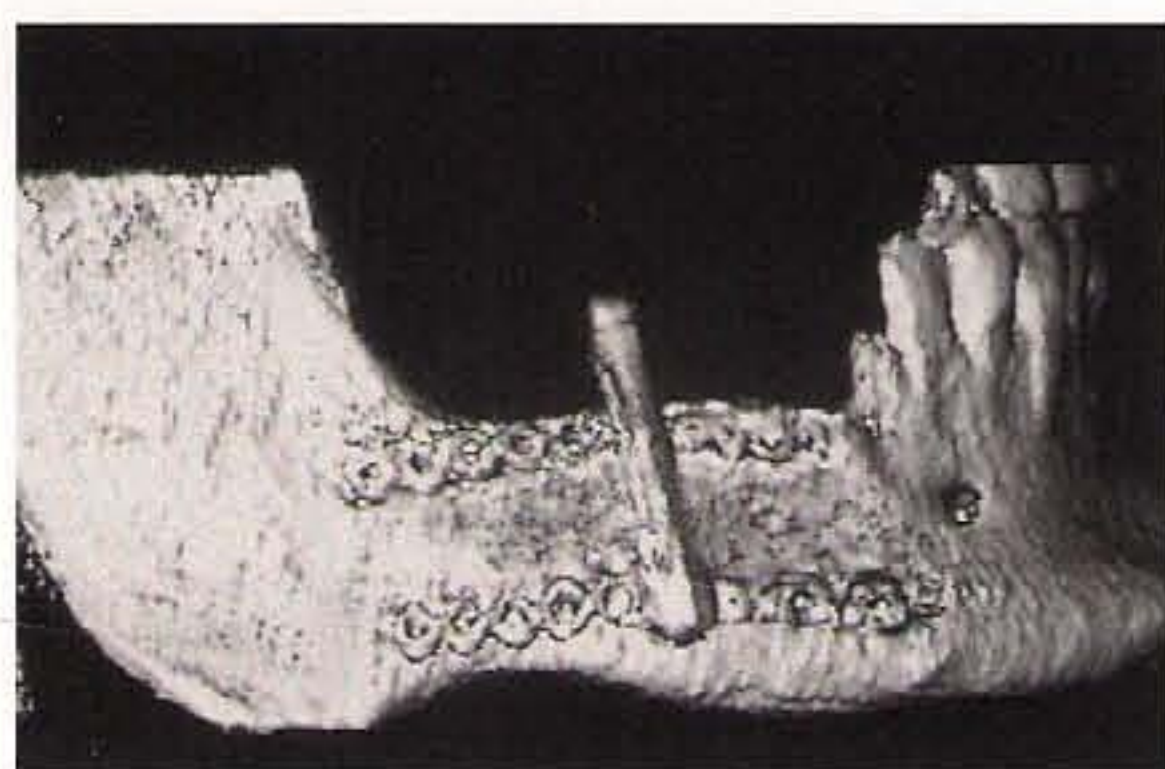


Fig 9-110 In a CT scan made 3 months after distraction, the 8-mm vertical augmentation of the crest is visible.

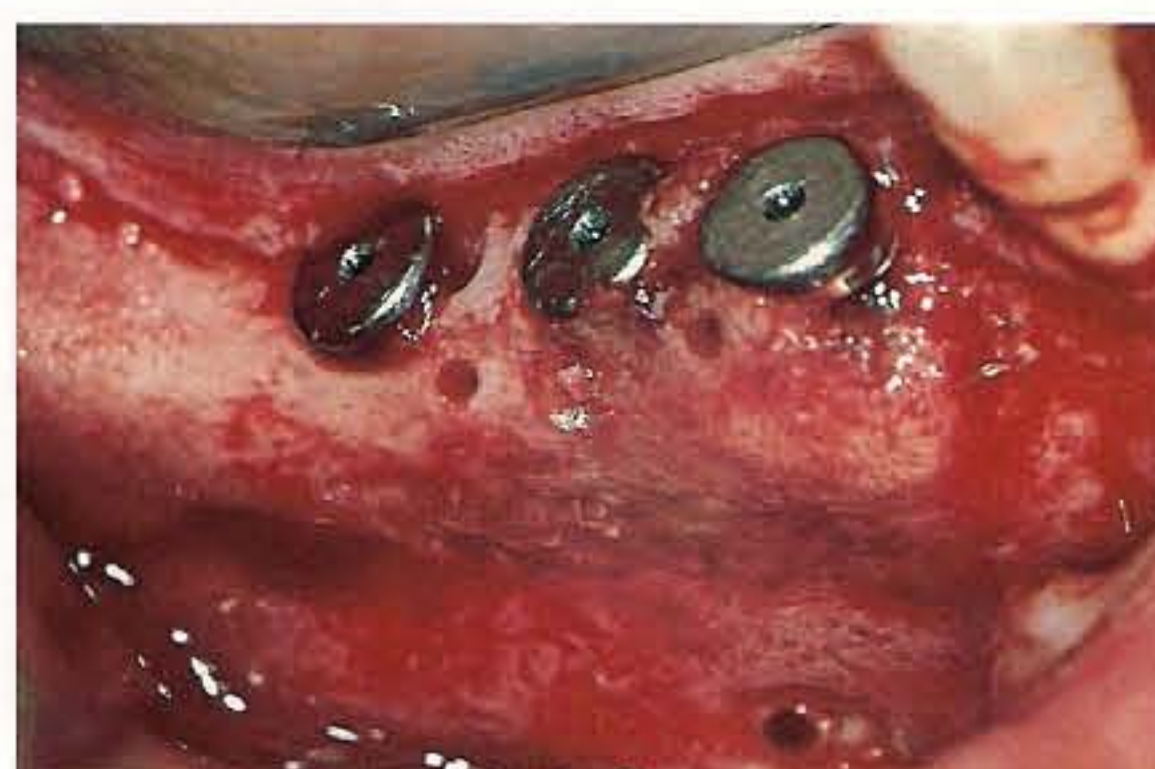


Fig 9-111 Three Brånemark implants are placed after removal of the distractor.



Fig 9-112 Clinical appearance prior to the stage 2 surgical intervention.



Fig 9-113 The healing abutment is connected.

Guided bone regeneration around implants

The technique of guided bone regeneration with the use of barrier membranes at peri-implant residual or postextraction bone defects, dehiscences, or fenestrations has proved effective when used by itself and in association with autografts or osteoconductive materials. Dahlin et al¹⁷¹ have shown that, in the presence of peri-implant bone fenestrations, only the mucoperiosteum positioned on the implant is not able to induce formation of new bone. When the regeneration technique and the use of membranes is combined, however, the percentage of exposed implant surface that is covered by new bone is increased.¹⁷²⁻¹⁷⁴

The membranes must be positioned on healthy and well-vascularized bone that is completely re-covered by soft tissue

and left in situ for the entire healing period (6 to 7 months for the maxilla)¹⁷⁵ (Figs 9-114 to 9-127).

Another essential condition for the formation of new bone at peri-implant dehiscences or fenestrations is the creation of a space available for the new bone. It is important to avoid the collapse of the membrane on the implant.¹⁷⁶ For this reason, membranes reinforced with titanium frameworks are available.¹⁷⁷ As an alternative, it is possible to interpose the patient's own bone or osteoconductive materials^{178,179} between the membrane and the implant¹⁸⁰ (Figs 9-128 to 9-133). In some cases, to increase the stability of the membranes, titanium microscrews can be placed in the intact bone. The same titanium screws can be used to increase the available space by distancing the membrane from the bone and hence impeding collapse.¹⁸¹

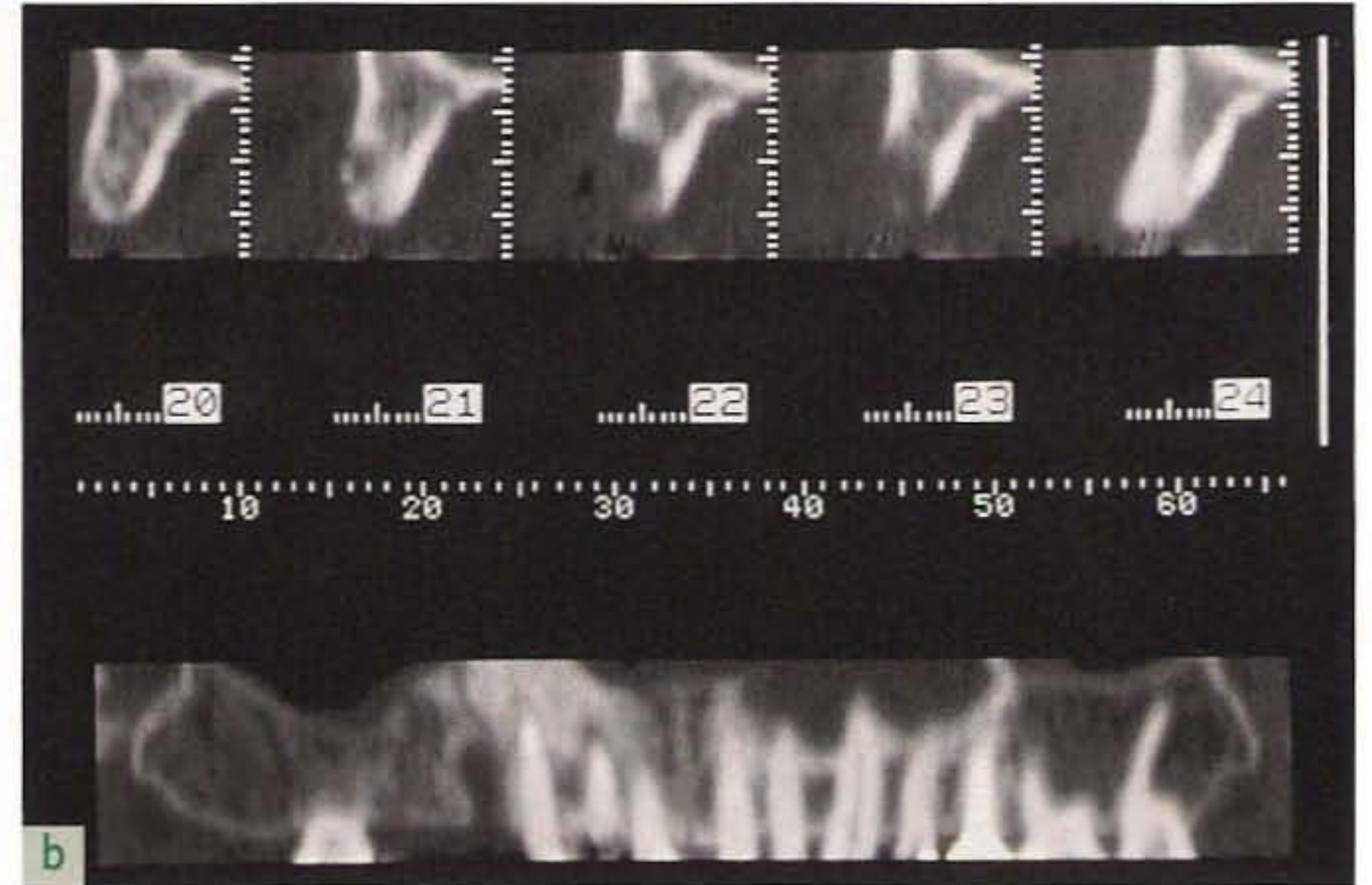
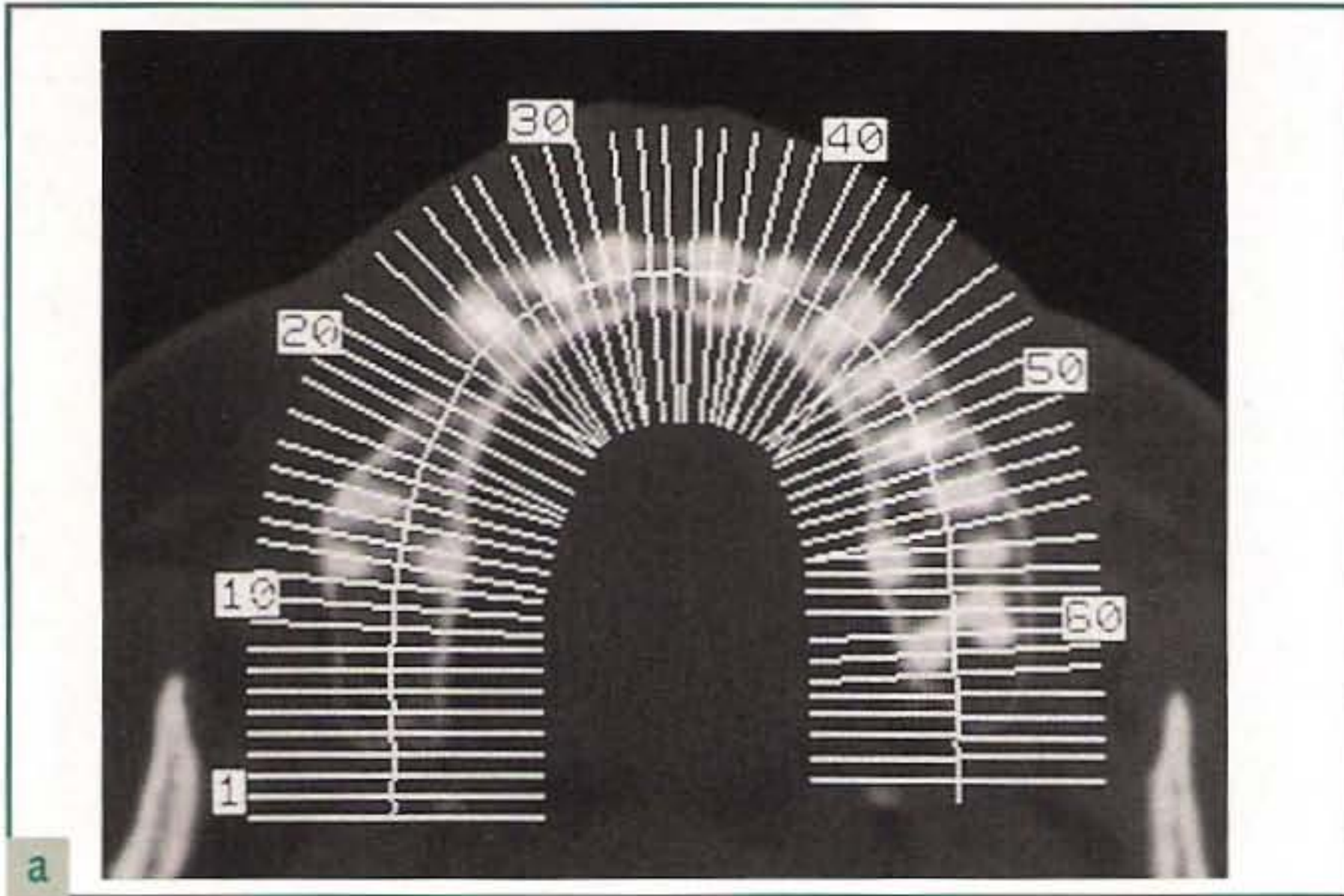


Fig 9-114 (a and b) The CT scan allows the deficiency of the residual bone around the maxillary right first premolar to be diagnosed. (Figs 9-114 to 9-127 courtesy of Dr Carlo Tinti.)

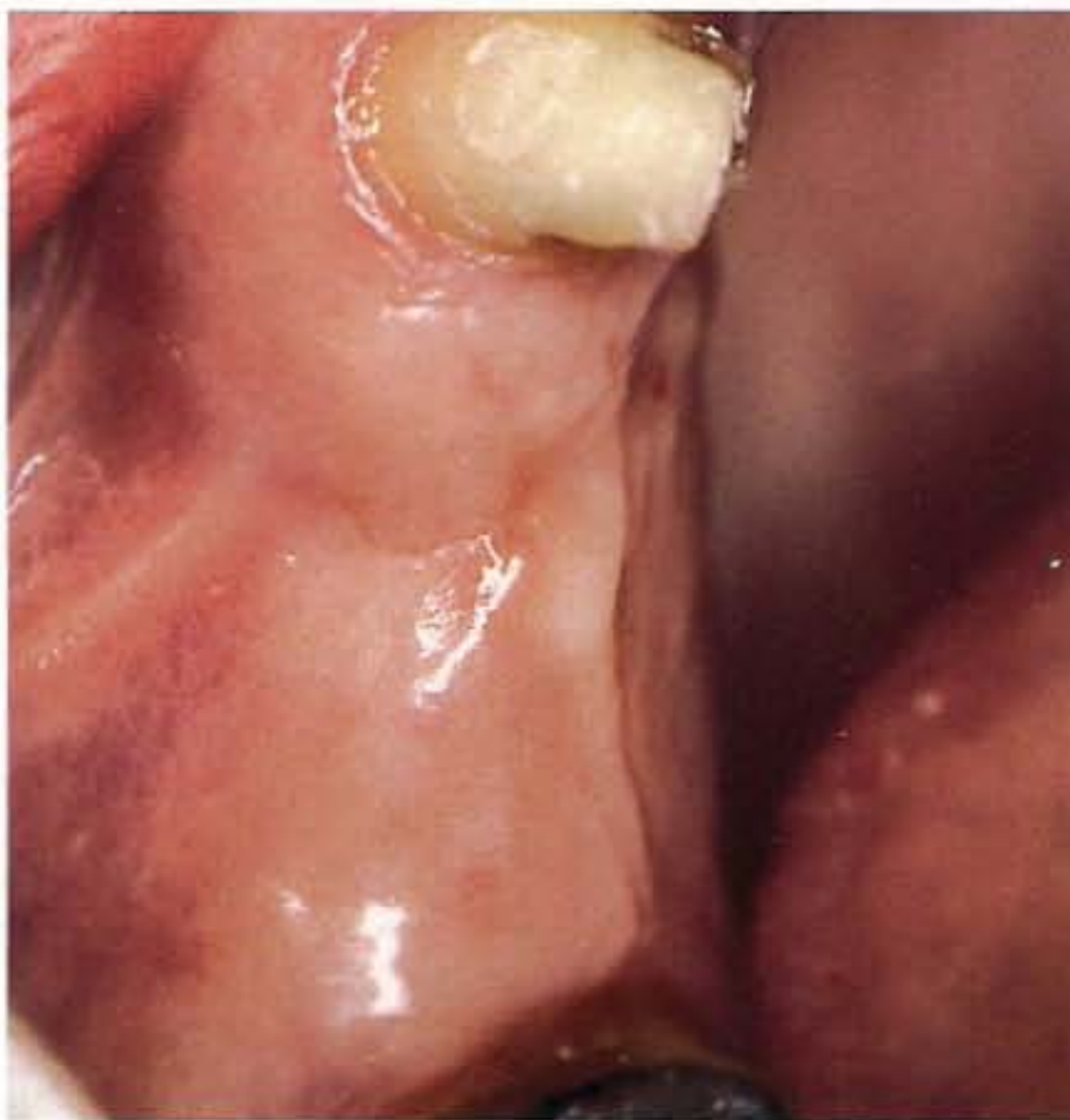


Fig 9-115 Clinical appearance of the soft tissues.

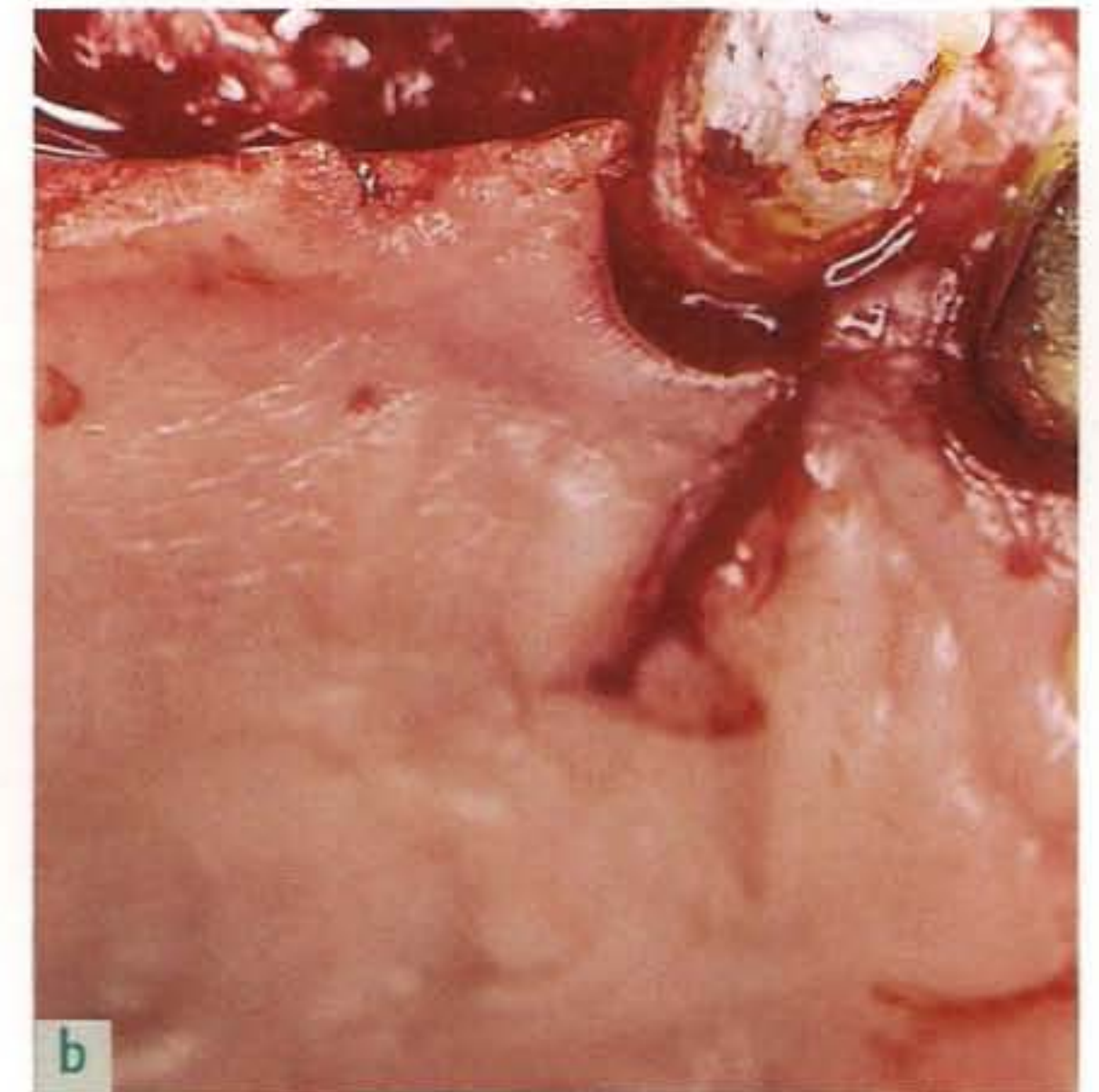
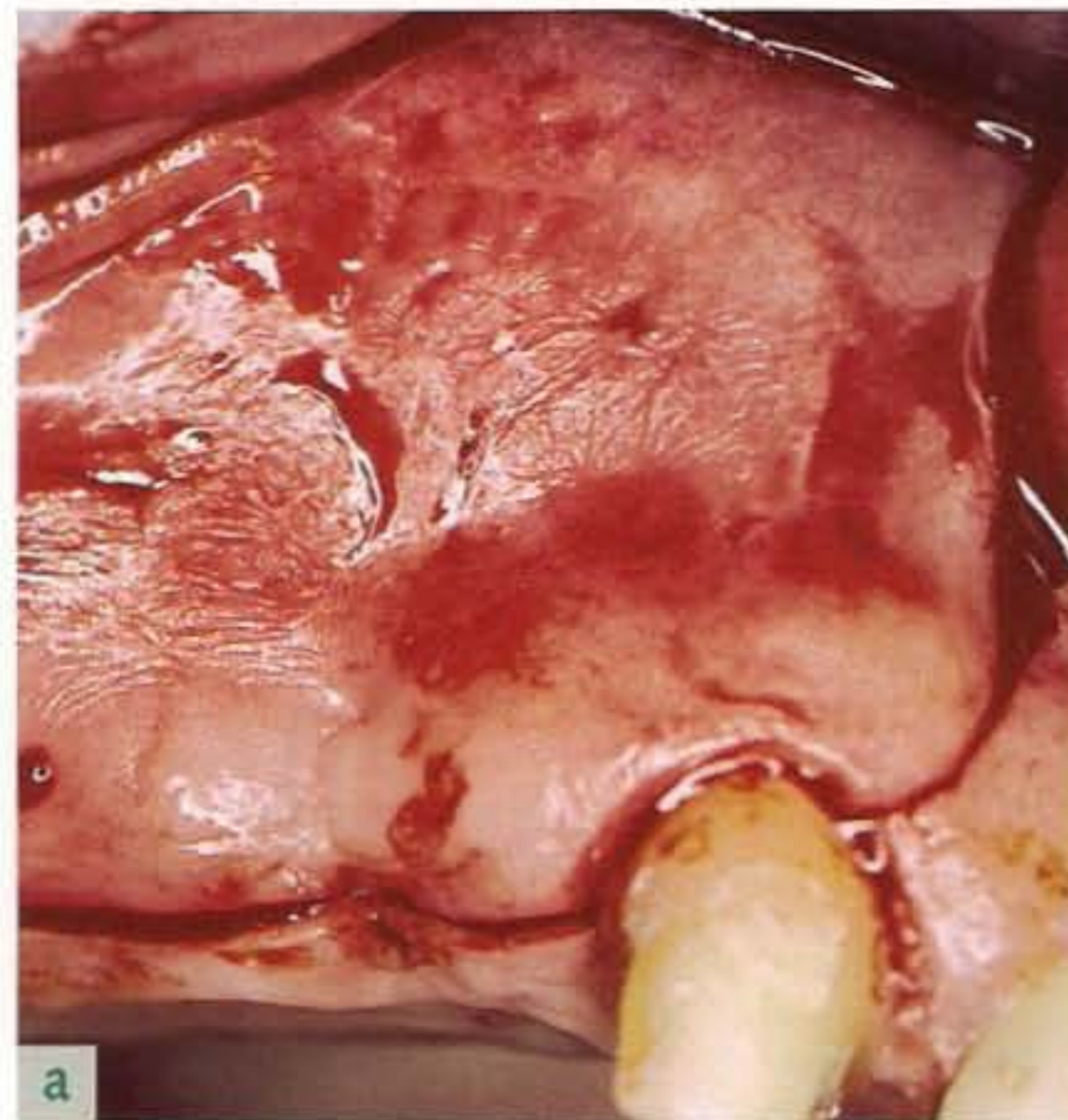


Fig 9-116 Incisions are made and the (a) buccal and (b) palatal flaps are outlined.



Fig 9-117 A full-thickness flap is raised to visualize the bone defect.

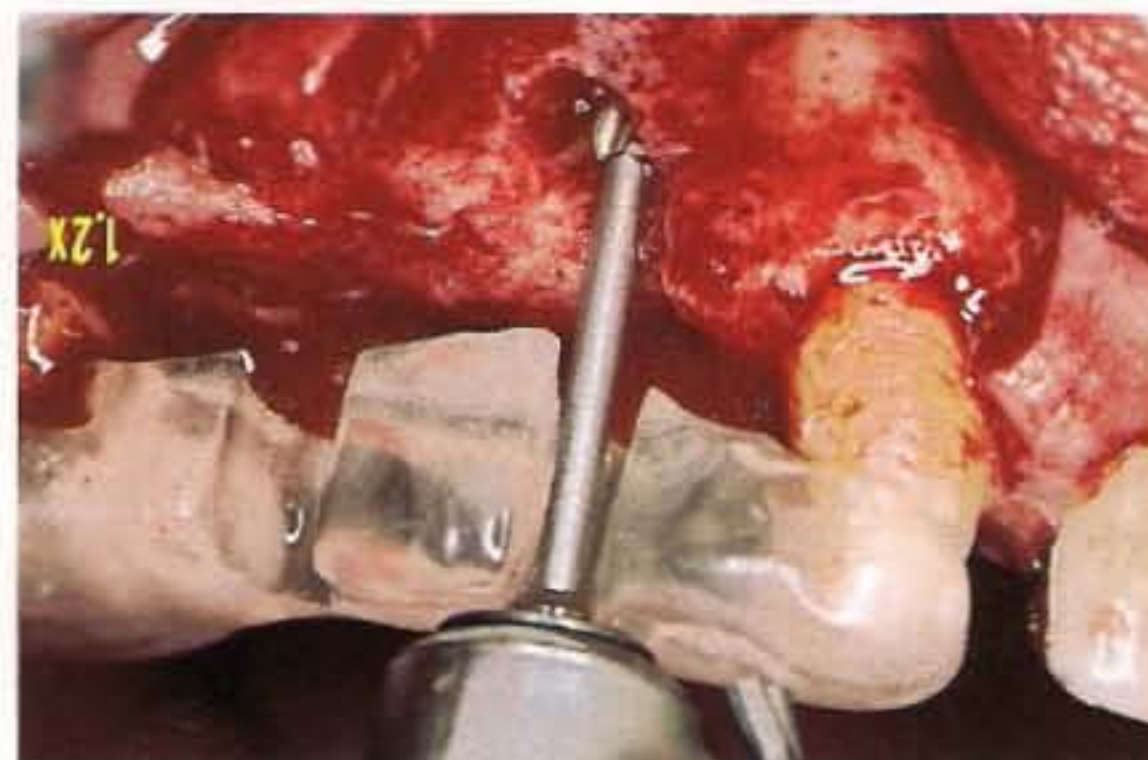


Fig 9-118 The implant site is prepared with the application of a surgical template.



Fig 9-119 The implant is in position. The buccal dehiscence defect is clearly visible.

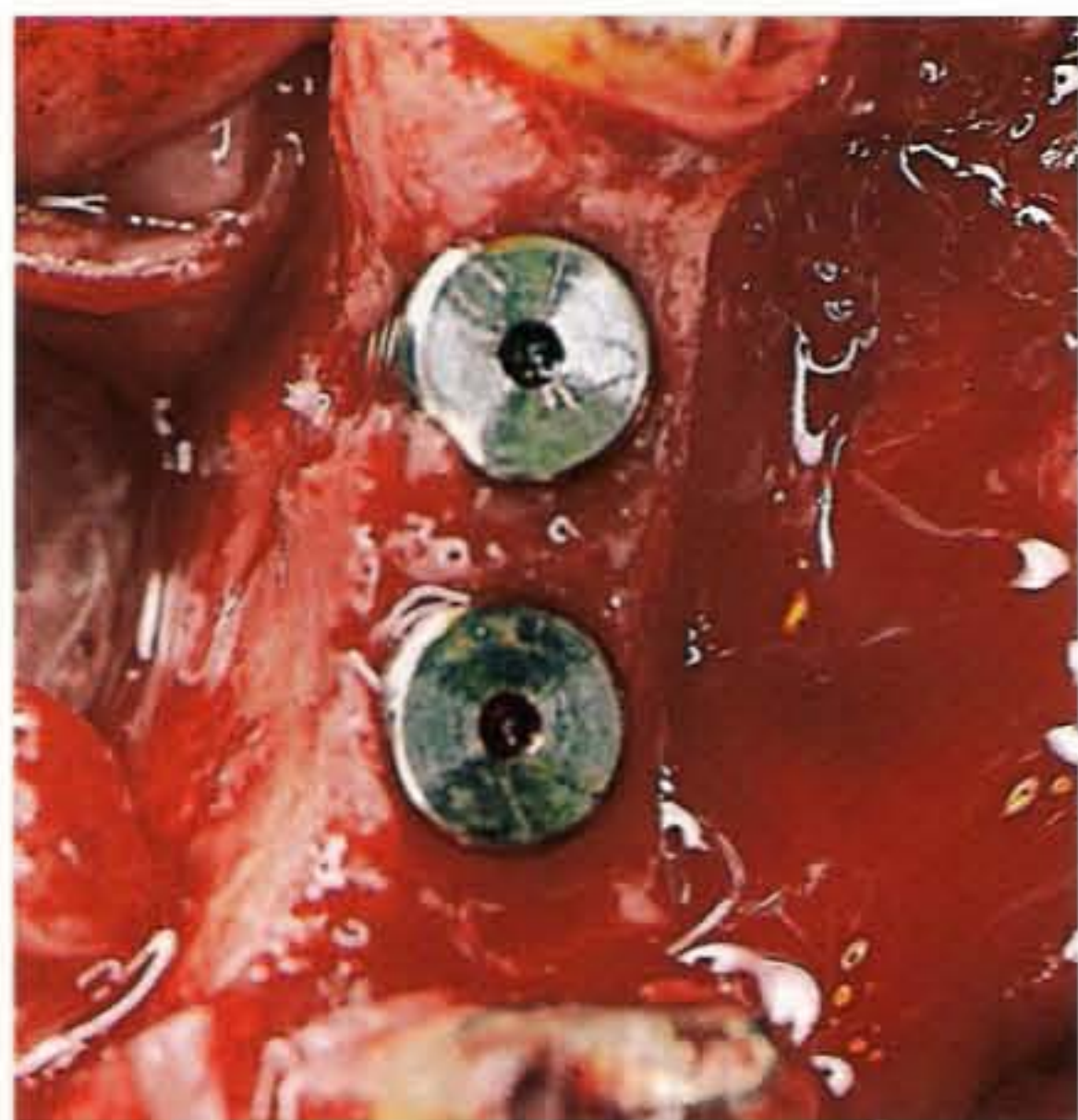


Fig 9-120 Architecture of the residual bone.



Fig 9-121 The exposed threads are protected with a titanium-reinforced barrier membrane.

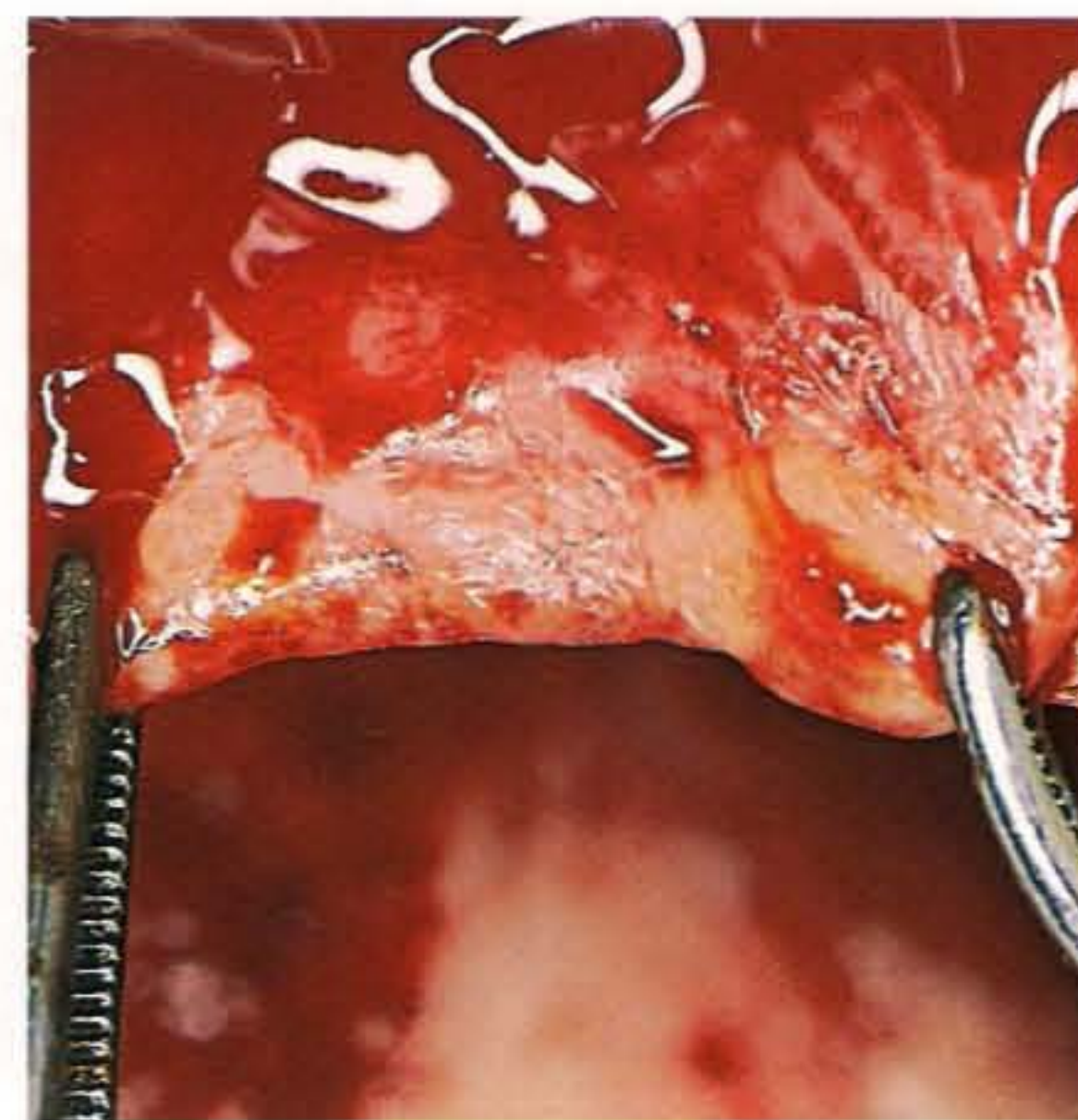


Fig 9-122 The flap following incision of the periosteum and the muscular fibers.



Fig 9-123 The flap is sutured.



Fig 9-124 After 10 months, there is total absence of inflammation and there is no exposure of the membrane.



Fig 9-125 A flap is reflected and the membrane is observed in situ.

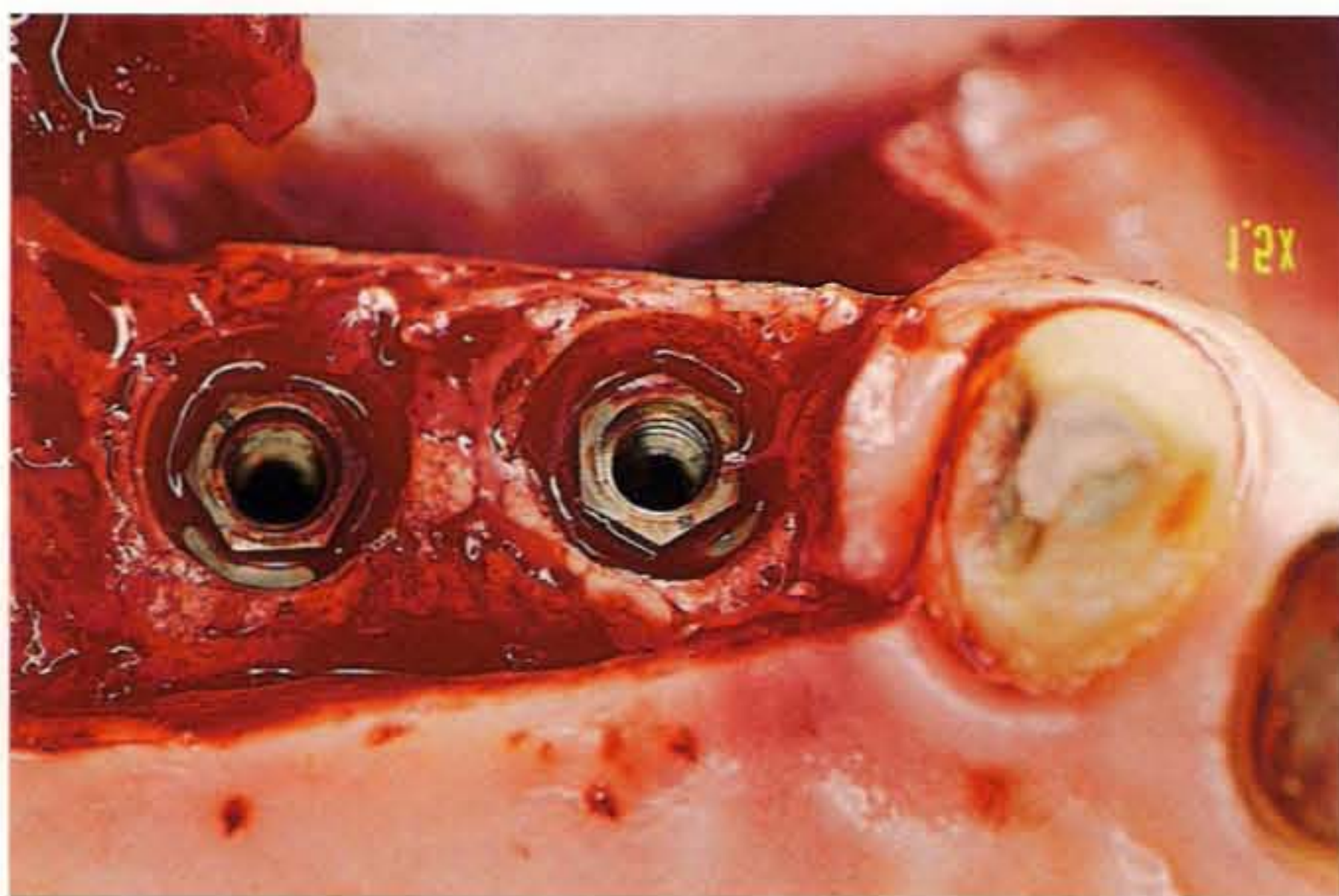


Fig 9-126 Complete bone regeneration. The implant is now perfectly centered in the new crest.



Fig 9-127 Six years after prosthetic restoration, the adaptation of the surrounding tissues can be defined as optimal.



Fig 9-128 A crestal reconstruction is performed in the mandibular left quadrant with a particulate bone autograft, harvested from the ascending ramus and finely ground.



Fig 9-129 Postsurgical radiograph.



Fig 9-130 Reopening after 6 months.

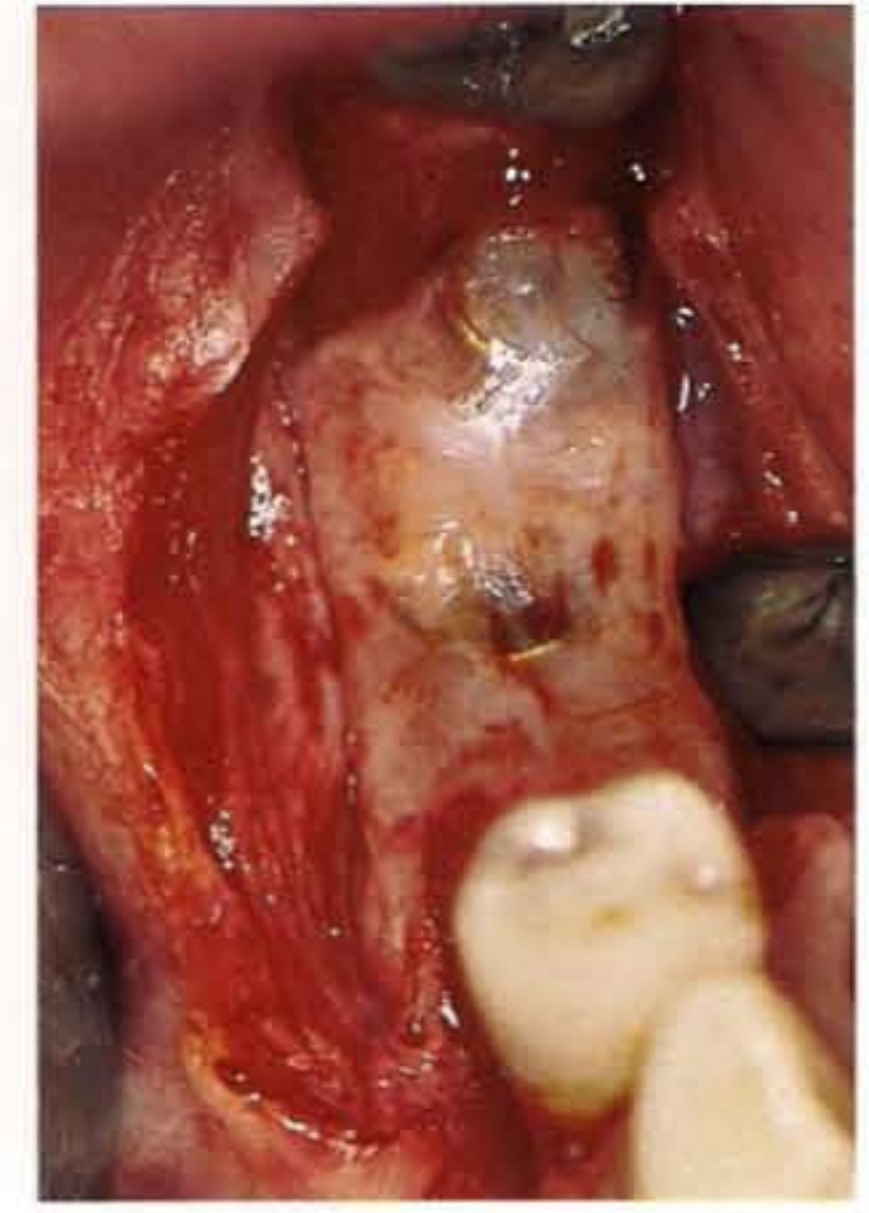


Fig 9-131 After the removal of the membrane, the newly formed bone is visible.



Fig 9-132 The new tissue covering the implant heads is removed.

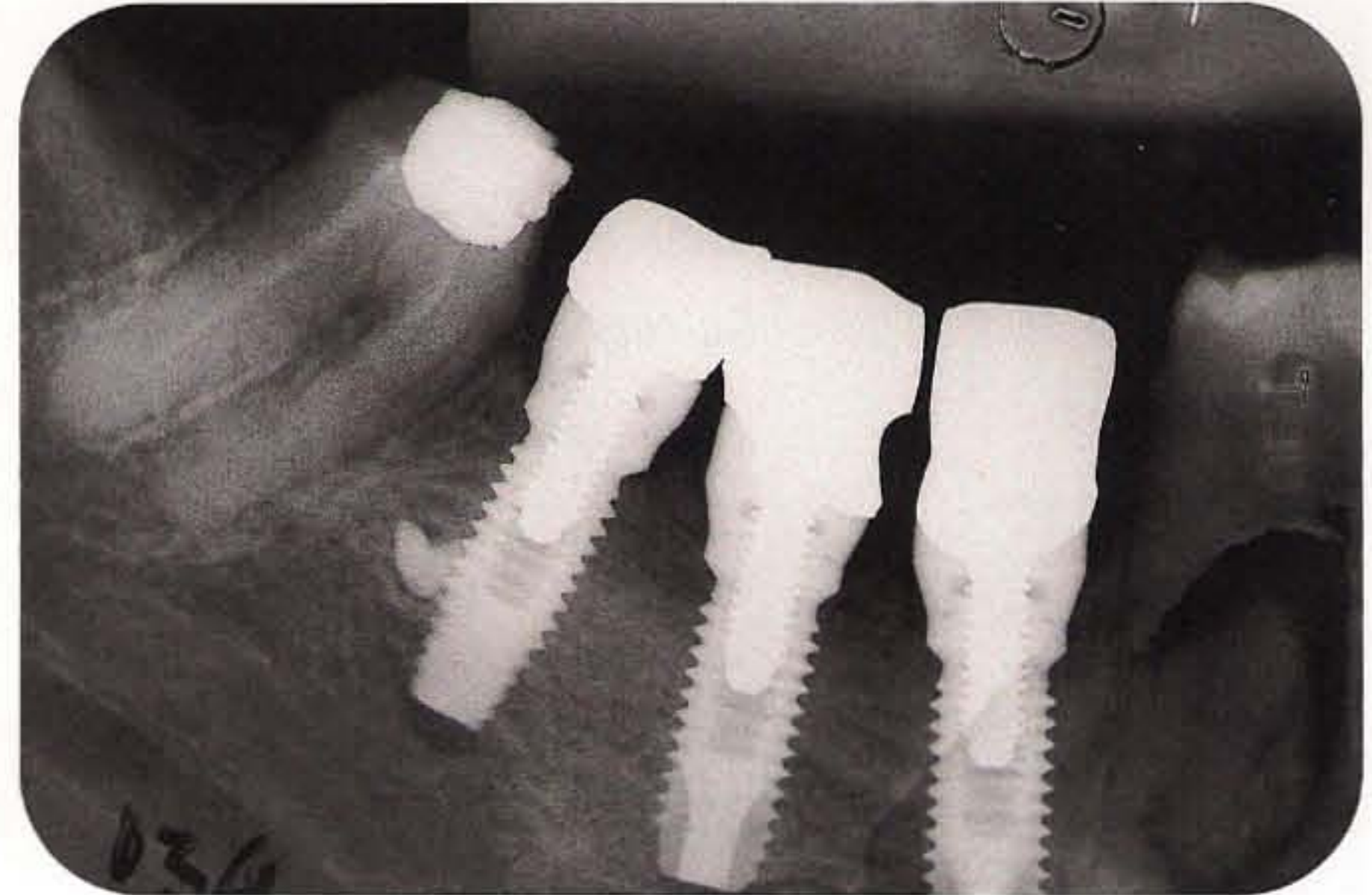


Fig 9-133 Radiograph 12 months after the prosthesis was placed.

The most common causes of failure of this technique are the collapse of the membrane on the wound and the premature exposure of the membrane through the soft tissues.¹⁸²

Vertical augmentation of the edentulous crest around implants

Vertical augmentation of the mandibular or maxillary edentulous crest around the whole circumference of the implant is possible by making use of the principles of the guided bone regeneration technique with a barrier membrane. Numerous researchers¹⁸³⁻¹⁸⁵ have developed surgical protocols that allow a 4- to 7-mm vertical recovery of bone around the implants

with a good predictability of success (Figs 9-134 to 9-144). The surgical protocol involves positioning of the implants in the edentulous crest, making use of the available bone, and allowing the part of the implants that must be re-covered by regenerated bone to emerge. The implants are covered with a reinforced membrane, which must be well stabilized on the residual bone. Beneath the membrane, in contact with the implants, the patient's or a donor's particulate bone or heterologous materials can be used to maintain the available space and facilitate osteoconduction.^{186,187} The healing time varies from 6 to 12 months.¹⁸⁸ All the evidence confirms that the newly formed bone is completely vital bone, similar to the bone that is formed during osseointegration.¹⁸⁹



Fig 9-134 Panoramic radiograph showing three implants in the mandibular right quadrant, affected by severe problems around the implant area. (Figs 9-134 to 9-144 courtesy of Dr Massimo Simion.)



Fig 9-135 After removal of the implants, severe atrophy of the bone crest is visible.

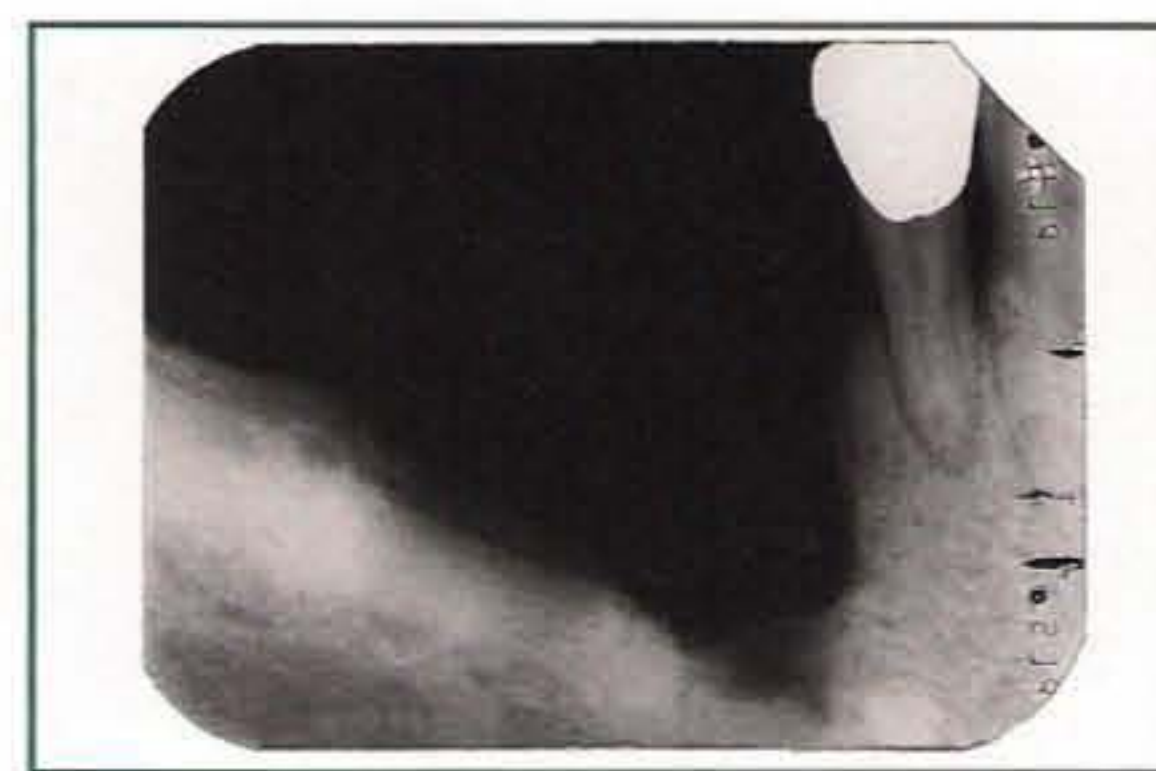


Fig 9-136 Intraoral radiograph showing the large vertical bone defect.

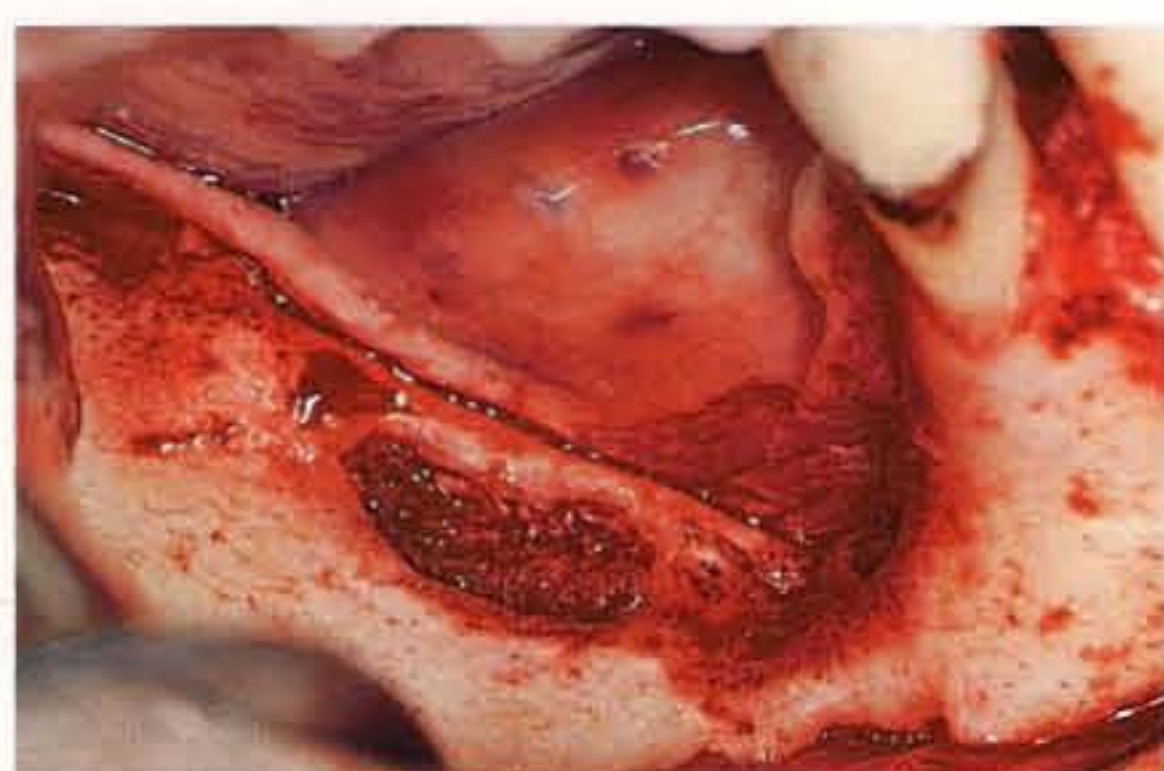


Fig 9-137 The mucoperiosteal flap reveals the bone defect.



Fig 9-138 The layer of cortical bone has been perforated to expose the medullary bone, and a 17-mm screw has been placed to support the membrane and maintain an adequate space.



Fig 9-139 The barrier membrane has been positioned over the defect and fixed with small screws. The space under the membrane has been filled with an autograft taken from the ascending ramus.



Fig 9-140 Postsurgical radiograph.



Fig 9-141 After 6 months of healing without complications, the membrane is removed.



Fig 9-142 Three Brånemark-type implants have been placed in the regenerated bone.

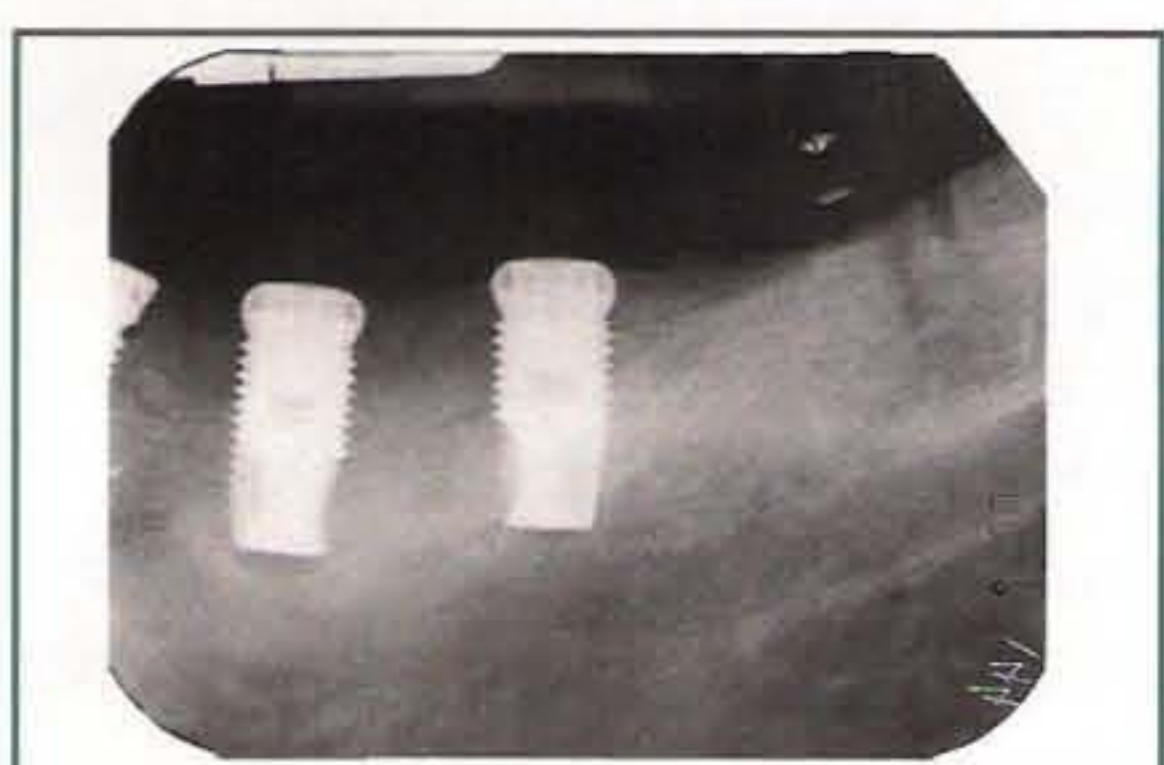


Fig 9-143 (far left) Radiograph of the implants.



Fig 9-144 (left) Radiograph taken 6 months after the placement of the prosthesis.

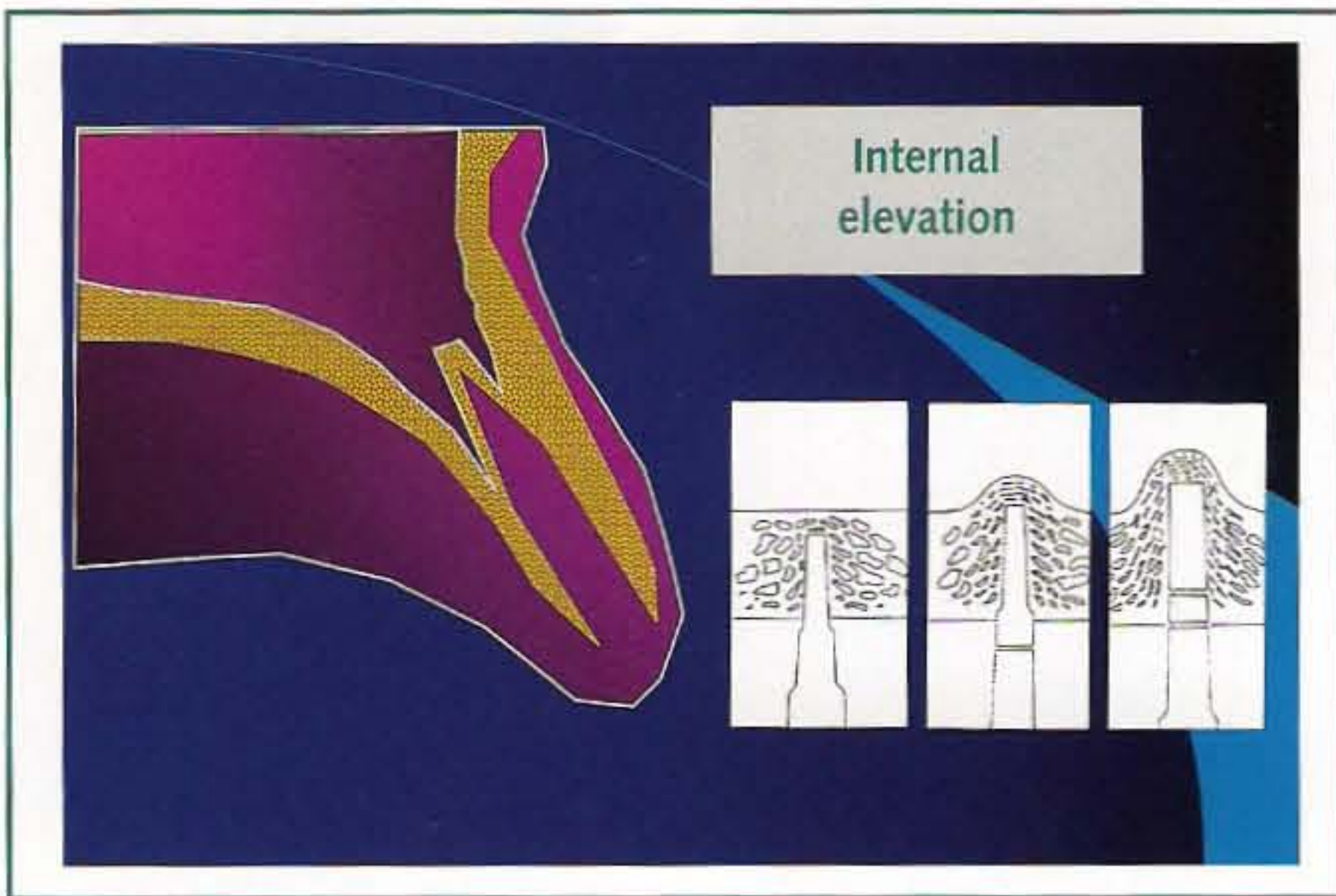


Fig 9-145 Vertical bone movement can be achieved with an osteotome.



Fig 9-146 The intraoral radiograph shows sinus floor elevation in association with a bone graft.

Osteotome technique for minor elevation of the sinus floor

The technique of minor elevation of the maxillary sinus (osteotome technique) was conceived by Summers in 1994¹⁹⁰ and is used exclusively in cases in which residual bone, in correspondence with the floor of the maxillary sinus, has a height of more than 5 mm. This technique is indispensable in terms of obtaining primary stability. With this technique, Summers¹⁹⁰ obtained a success rate of 96% after 5 years for 143 implants inserted in 46 patients. With the standard protocol, the use of drills and hence the destruction of the bone are required; with osteotomes, in contrast, the bone is maintained and compacted. Scipioni and collaborators¹⁹¹ and Bruschi et al¹⁹² have modified Summers' technique by changing the form of the osteotomes. When osteotomes of increasing diameters are inserted forcefully in the osseous tissue, the impact results in both a compression that increases the osseous density and an apical movement of bone and relative increase in height.

During the vertical condensation maneuver, the floor of the maxillary sinus is fractured and the sinus membrane is raised. An elevation of more than 5 mm carries the risk of perforation of the membrane. This technique provides a potential 1- to 2-mm vertical increase without the use of graft materials. With the use of graft materials, the last phase of condensation is carried out after the graft materials are positioned in the apical parts of the prepared site and subsequent use of the final, widest diameter osteotome. This allows a more uniform distribution of the forces applied by the osteotome to the residual bone, with a minor risk of perforation of the membrane (Figs 9-145 to 9-147).

If bone tissue is present on the palatal surface of the maxillary sinus, Scipioni and collaborators¹⁹¹⁻¹⁹³ proposed the use of

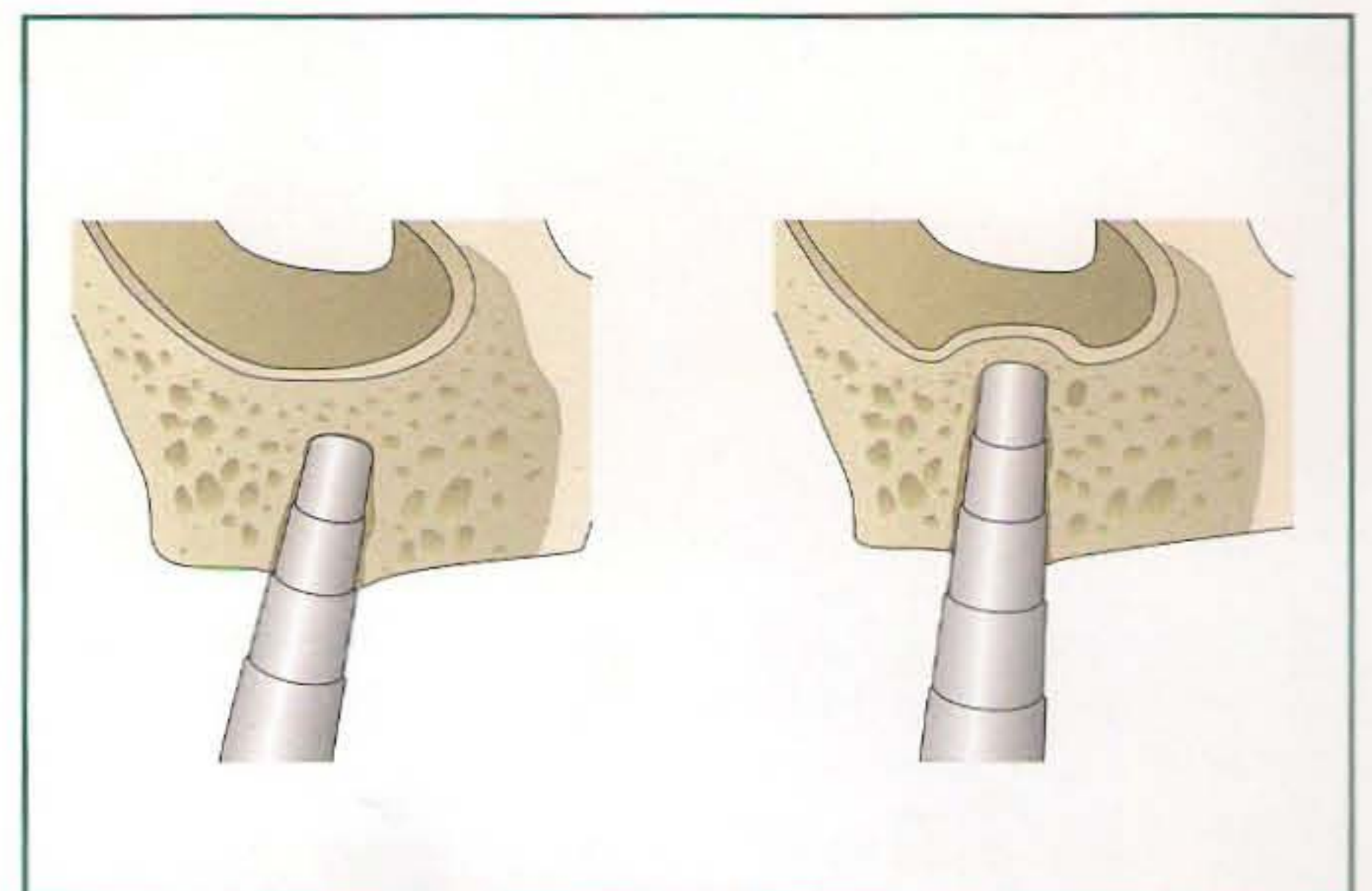


Fig 9-147 Elevation of the maxillary sinus floor.

a lateral osseous shift with consequent elevation of the sinus using osteotomes of progressively greater diameters. The lateral shifting is accomplished by modifying the axis of insertion of the osteotomes, which initially assume a more palatal angulation; successively, in the condensation phases, a vertical motion is applied with the osteotome, which has been redirected buccopalatally (Figs 9-148 to 9-176).

In a multicenter study by Rosen et al¹⁶⁰ examining the technique used by Summers and others, 174 implants were inserted in 101 patients with a success rate of 95.5% after 20 months. The same research indicated that, for this technique, implants with a rough surface are more advisable than those with a smooth surface.¹⁶⁰

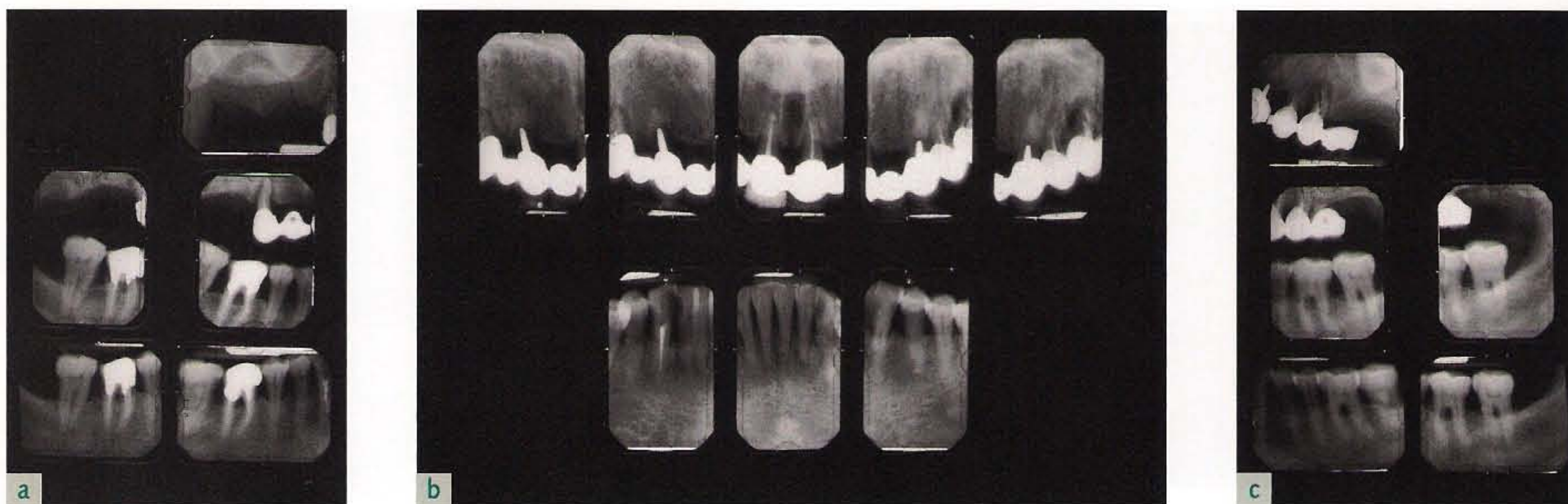


Fig 9-148 (a to c) Systematic radiographic evaluation of one patient. (Figs 9-148 to 9-176 courtesy of Dr Gaetano Calesini.)



Fig 9-149 Condition of the maxillary arch after removal of existing restorations and the extraction of the maxillary right canine, left canine, and left second premolar.



Fig 9-150 Provisional reinforced-resin prosthesis.



Fig 9-151 Condition of the maxillary arch at the time of insertion of the second provisional restoration, after 15 days of the initial prosthesis.



Fig 9-152 Preoperative radiograph in the maxillary right molar region. Around area of the first molar, the height of the bone crest is 9 mm; near the area of the second molar, it is about 10 mm.



Fig 9-153 Preoperative radiograph of the maxillary right premolar region. The second premolar, which was used as an abutment for the provisional restoration, is periodontally compromised. The vertical dimension of the bone around the first premolar is well preserved and will be used for placement of the implant.



Fig 9-154 A buccally repositioned partial-thickness flap is executed. The alveolar crest is still covered by thin connective tissue with the periosteum left in situ.

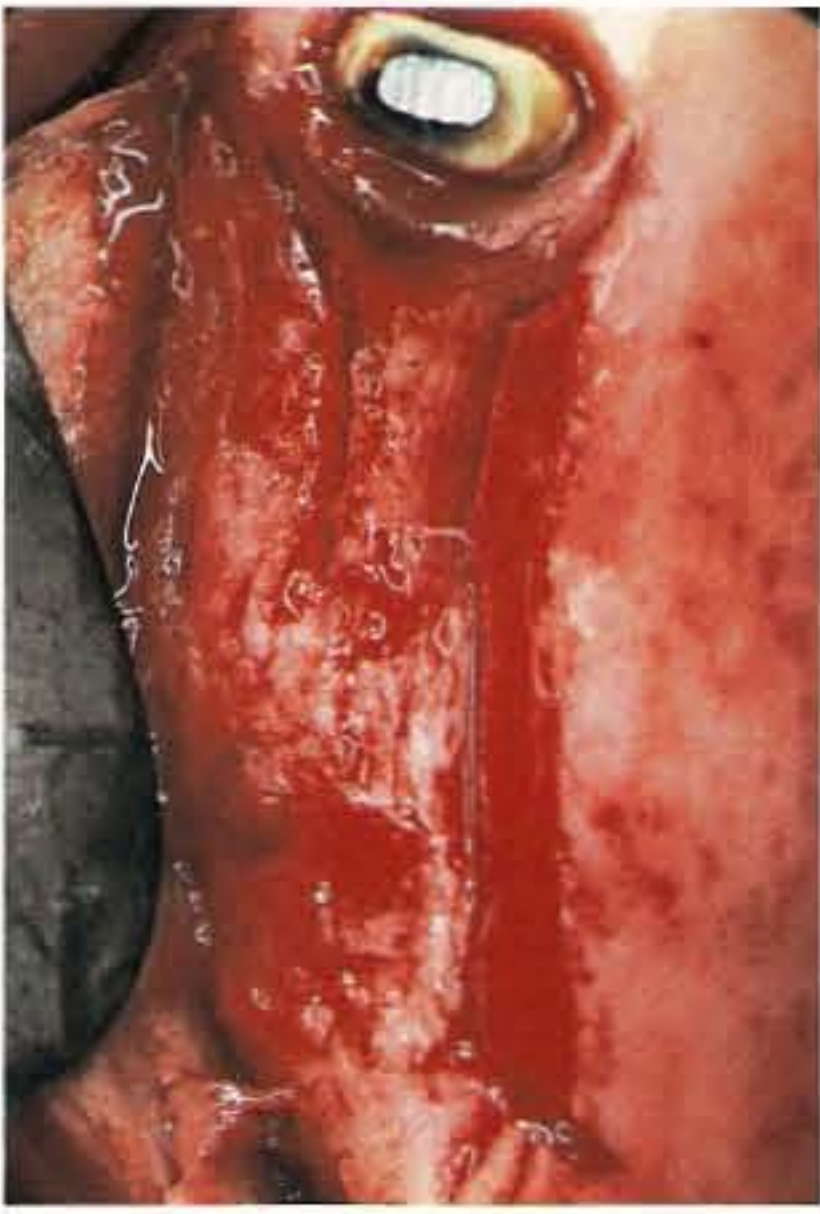


Fig 9-155 The same technique is used to execute a flap in the molar area. The small palatal incision is sufficient to check the condition of the palatal surface of the alveolar bone crest.

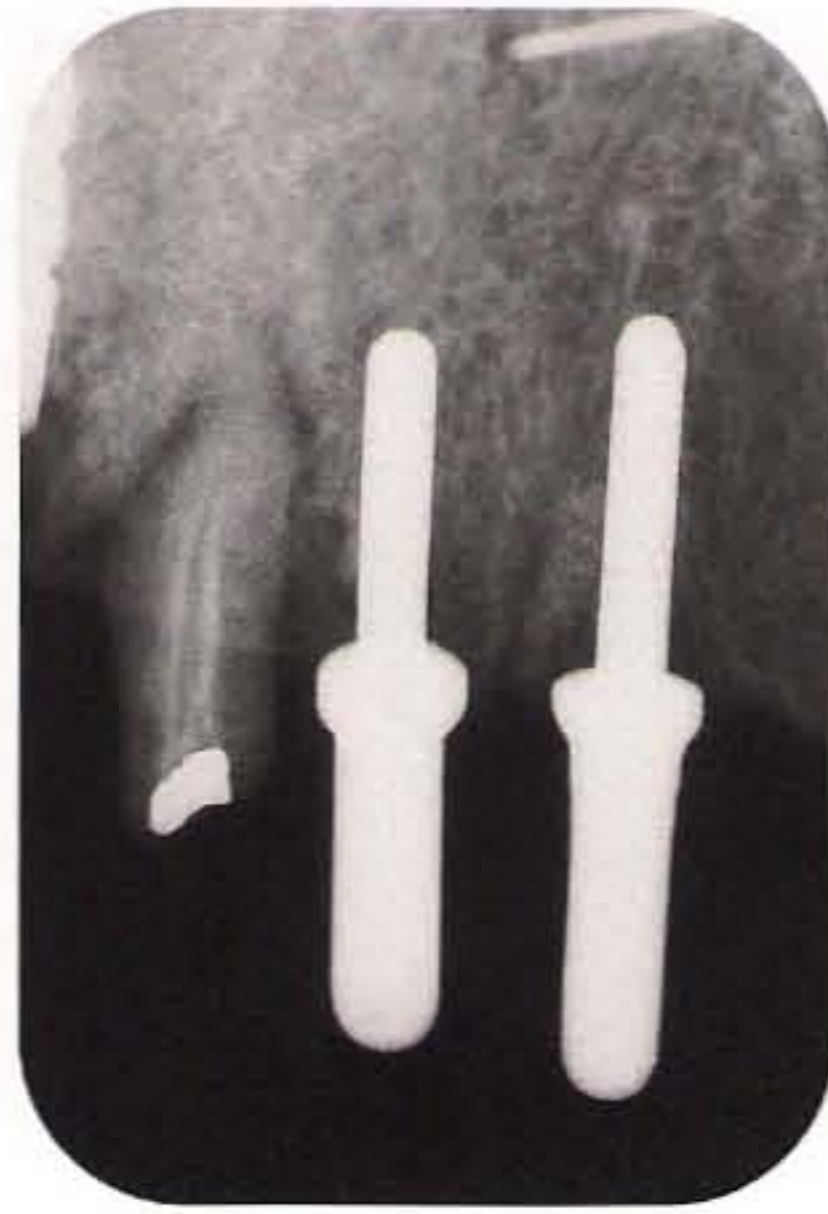


Fig 9-156 A radiograph is taken during the procedure with directional indicators inserted at 10-mm depth in the positions of the canine and first premolar, to verify that the anatomic relationship is correct.



Fig 9-157 The occlusal surface is shown after the horizontal expansion obtained with the edentulous ridge expansion technique. The holes are not rounded, because they were obtained with the use of expanders.



Fig 9-158 Radiograph to confirm the correct insertion of the implants. The radiolucency of the crestal area is the result of coronal crestal expansion with the edentulous ridge expansion technique.

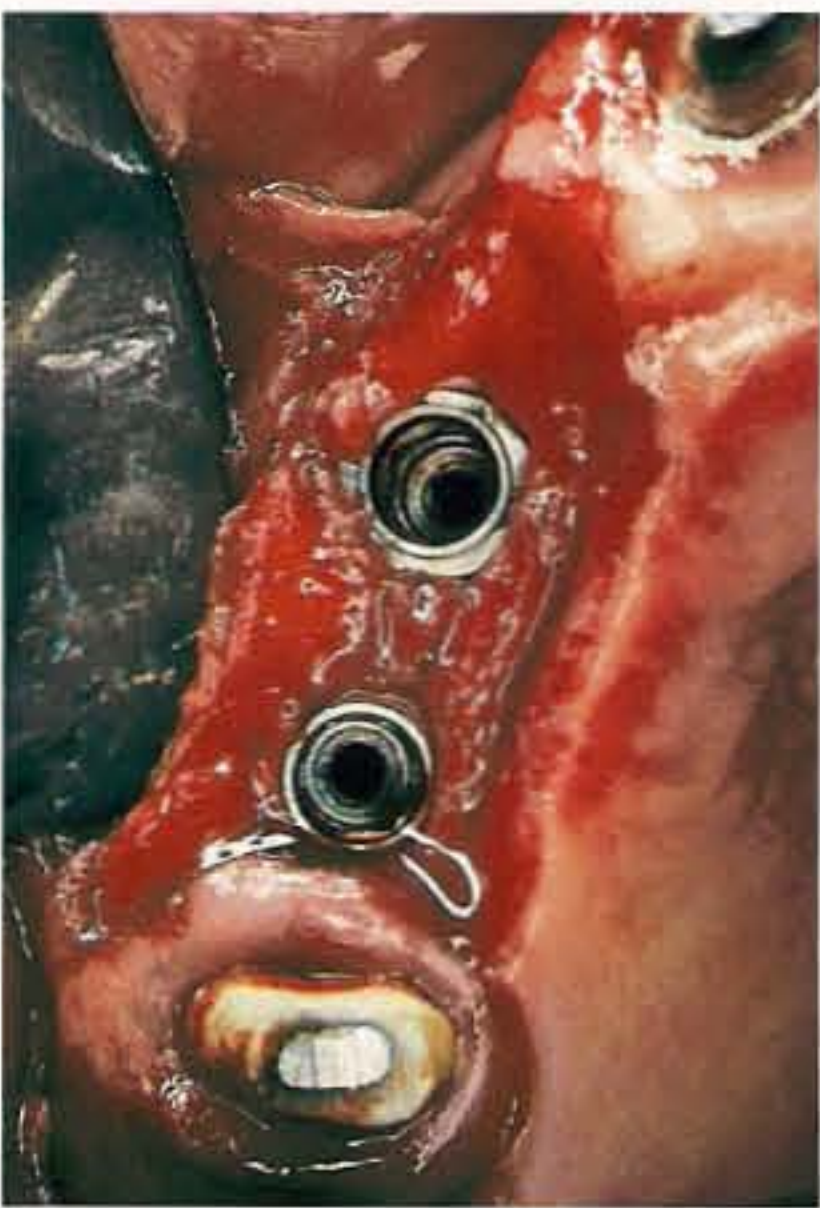


Fig 9-159 Coronal view of the inserted implants. The correction of the buccal profile of the hemiarch is clearly visible.

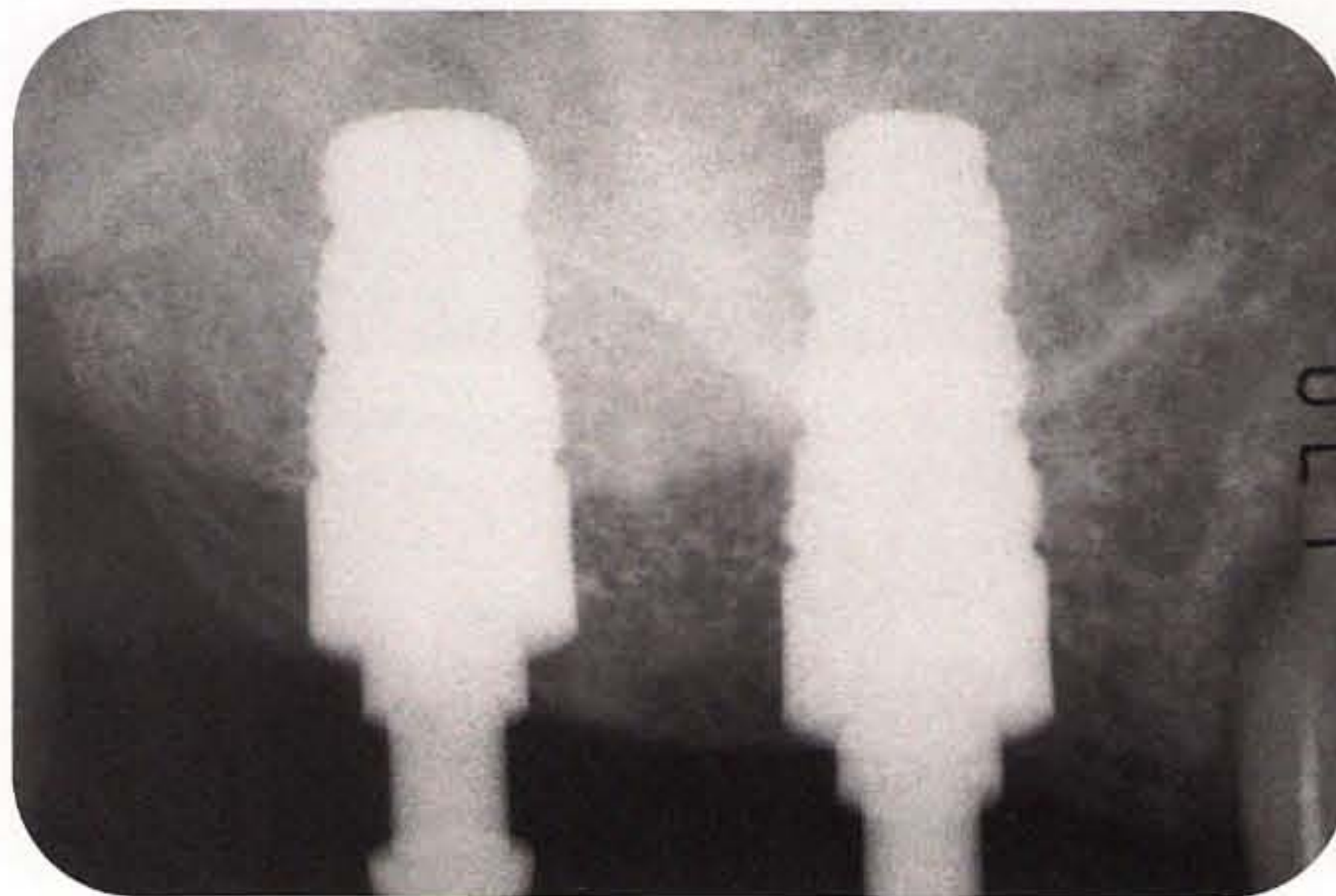


Fig 9-160 Radiograph to verify the correct placement of implants in the molar area. The radiograph reveals the correct positioning of the implants in relation to the alveolar crest. In addition, the sinus floor elevation, about 6 to 7 mm in the region of the first molar and 3 mm in the area of the second molar, is visible. The technique known as *localized management of sinus floor* was used.



Fig 9-161 Occlusal view after placement of the implants in the areas of the first and second molars.



Fig 9-162 A radiograph of the left premolar region reveals a vertical fracture of the maxillary left second premolar, with consequent bone damage, and a subcrestal caries lesion on the canine.



Fig 9-163 Pretreatment radiograph that shows the persistence of the bone lesion supported by the buccal root of the first premolar. Before the preparation of the implant site, a resection of the buccal root will be performed.

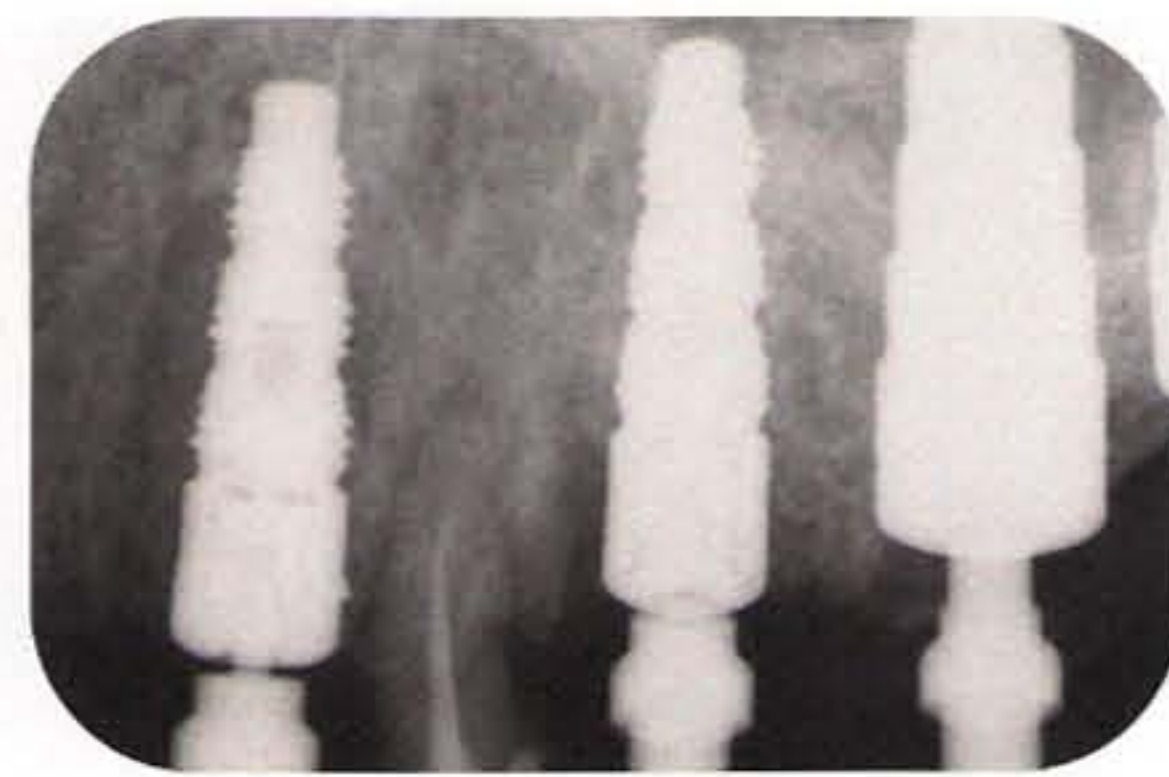


Fig 9-164 Radiograph to confirm the correct placement of the implants in the positions of the canine and second premolar.



Fig 9-165 The alveolar implant site preparations in the positions of the first and second molars have been formed by the bone expander without the use of drills and are ready to accept implants.

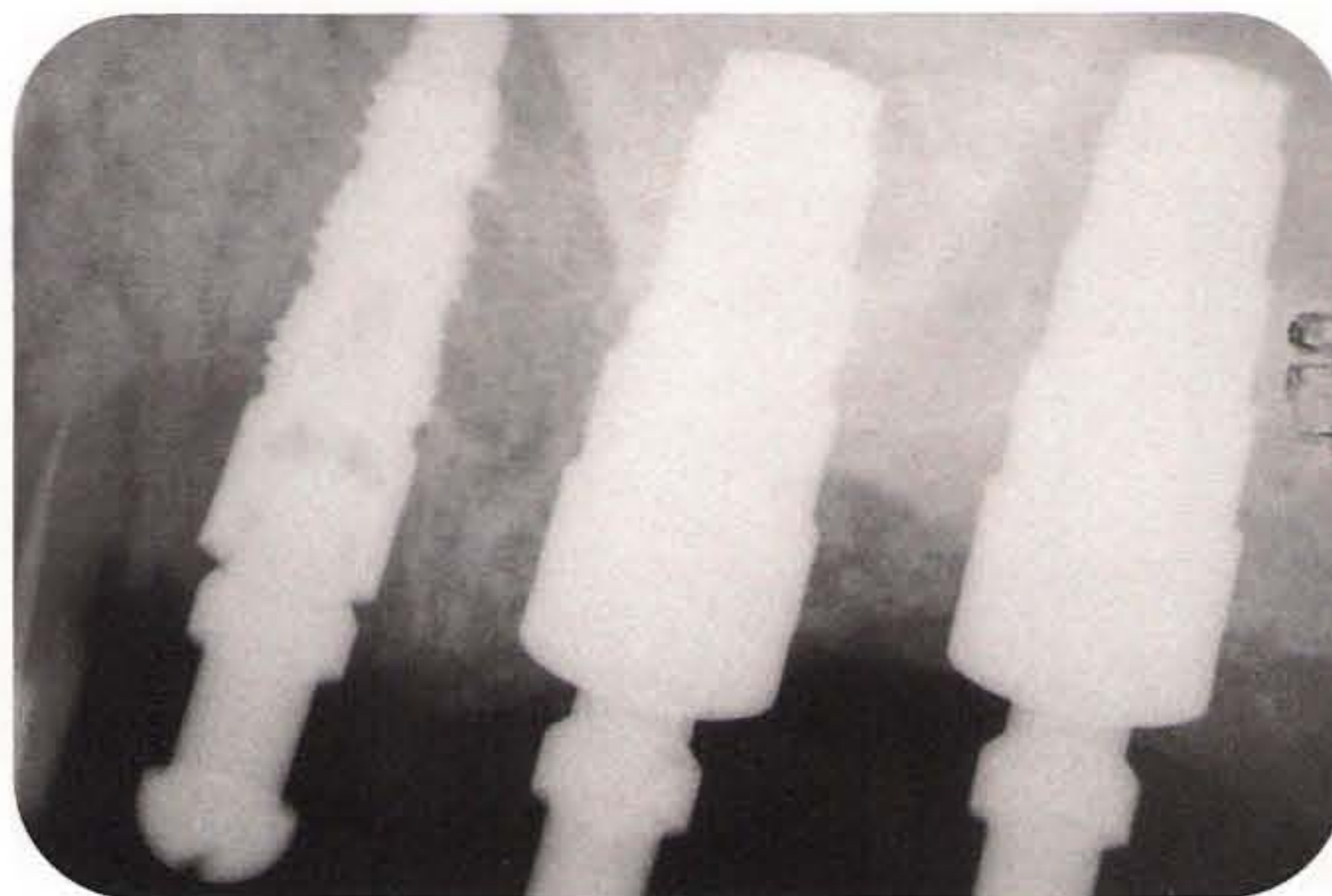


Fig 9-166 Radiograph to check the correct placement of the implants for the second premolar, first molar, and second molar. Note the correct positioning and dimension of the elevated maxillary sinus, particularly around the molars. The sinus floor has been elevated by 8 mm in the molar area. Localized management of the sinus floor was used.



Fig 9-167 Occlusal view after placement of implants on the left side of the arch. Stage 2 surgery for all the implants was made in one appointment, 5 months after insertion on the right side of the arch and 4 months after insertion on the left side.

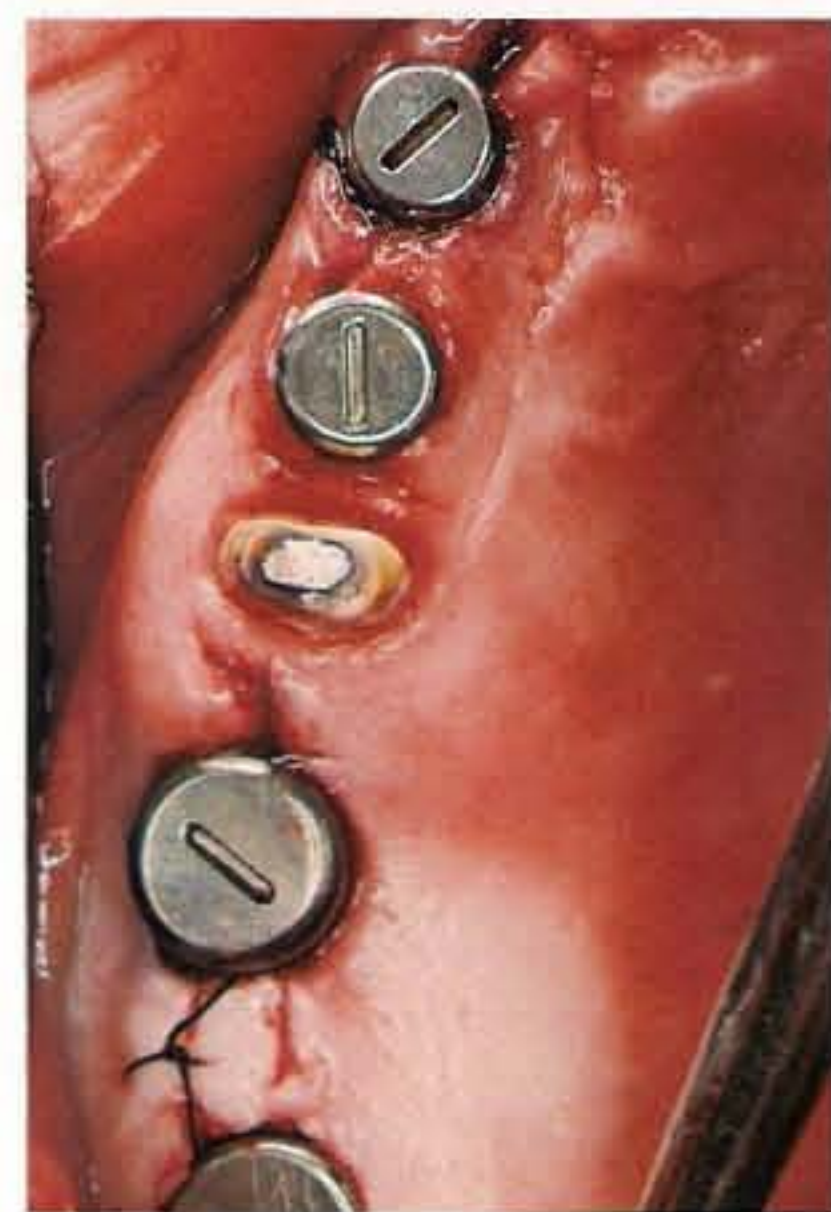


Fig 9-168 (*far left*) The healing abutments are in place on the right side. The surgical intervention was performed with simple longitudinal incisions of the crest.



Fig 9-169 (*left*) The healing abutments have been placed in the left side of the arch. The same opening technique was used. The horizontal distraction of the soft tissues and the vertical increase of the gingiva are evident. The central zone, healed by secondary intention, allows a further increase in the keratinized mucosa and formation of the interproximal papilla.

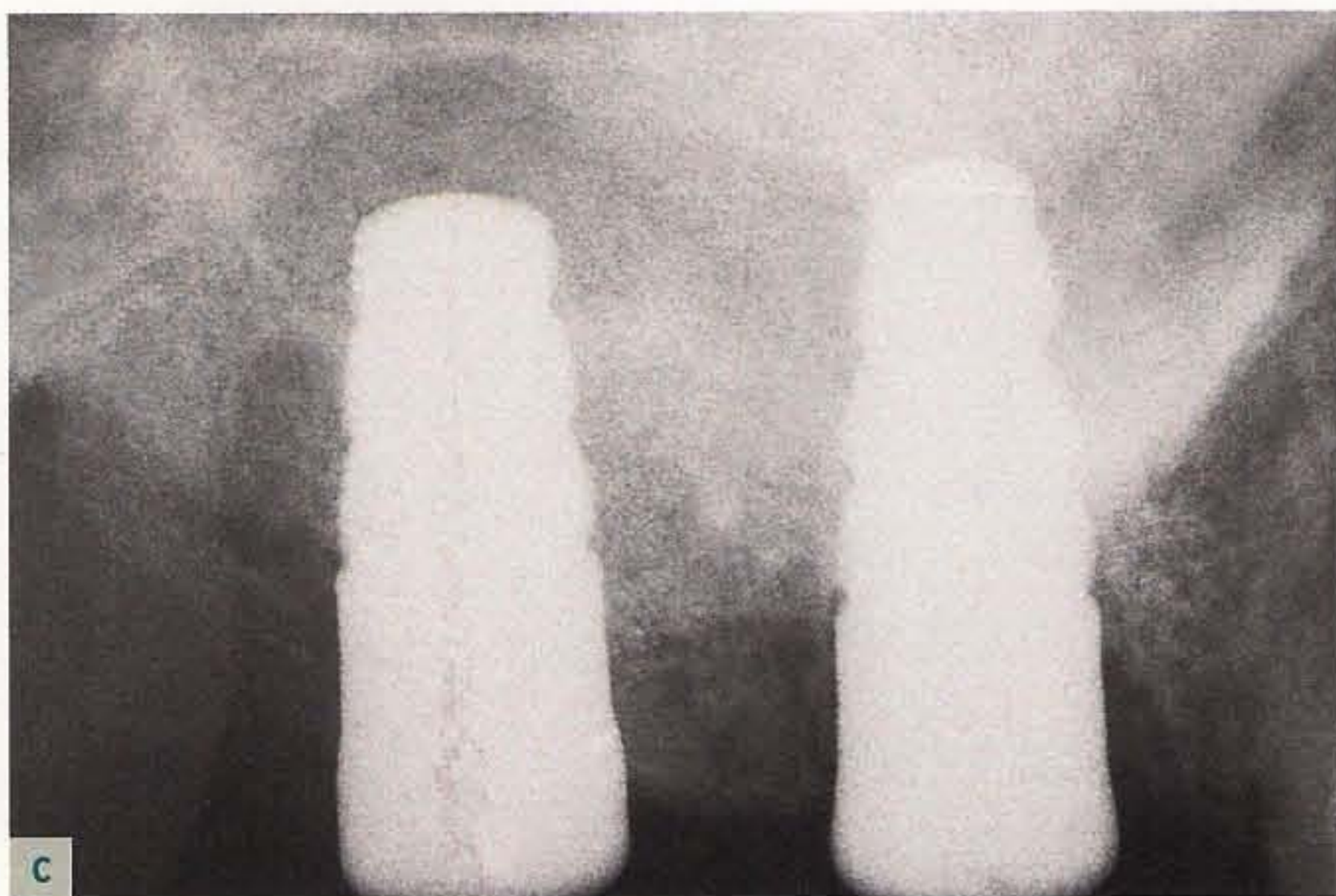
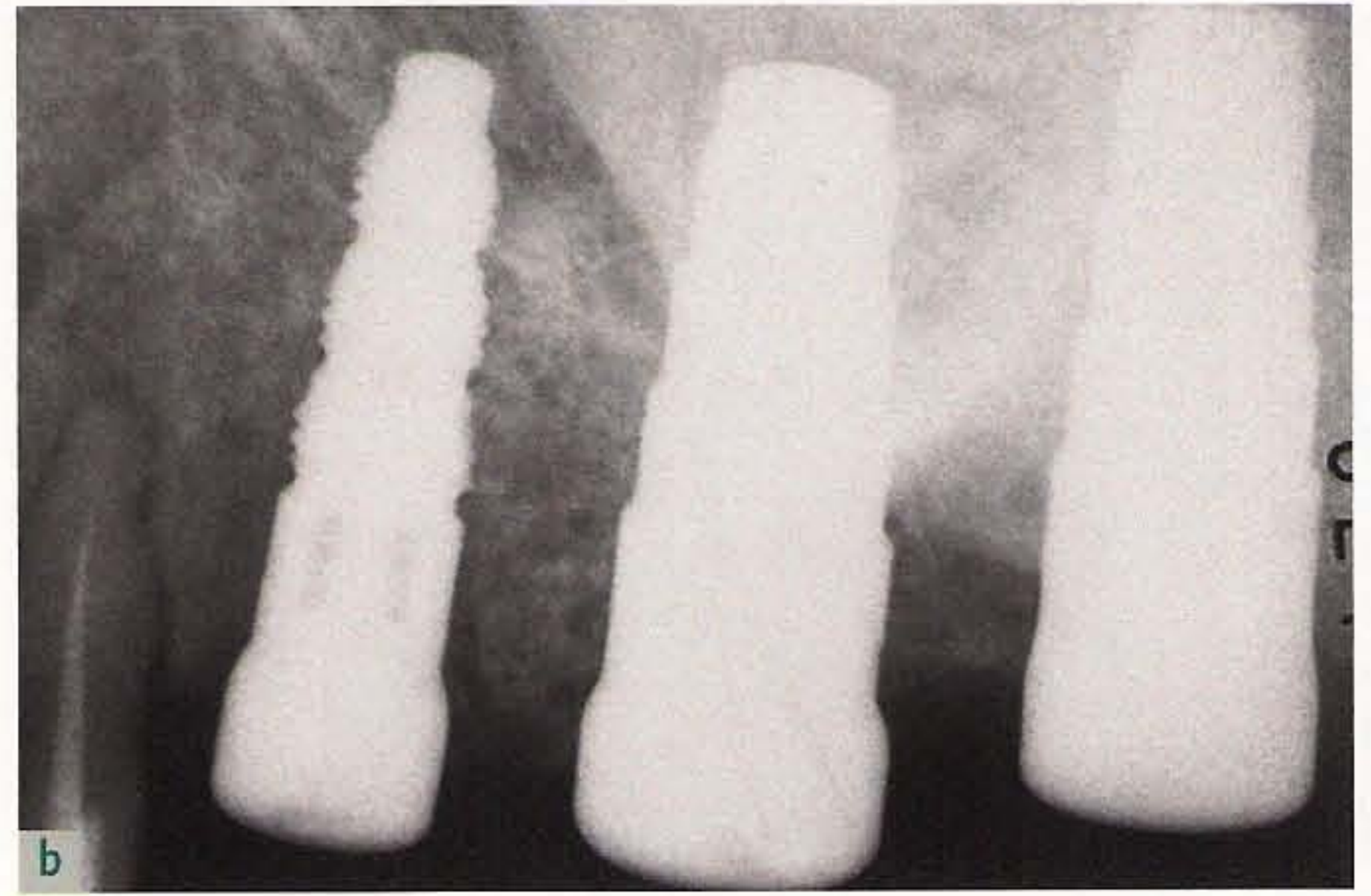
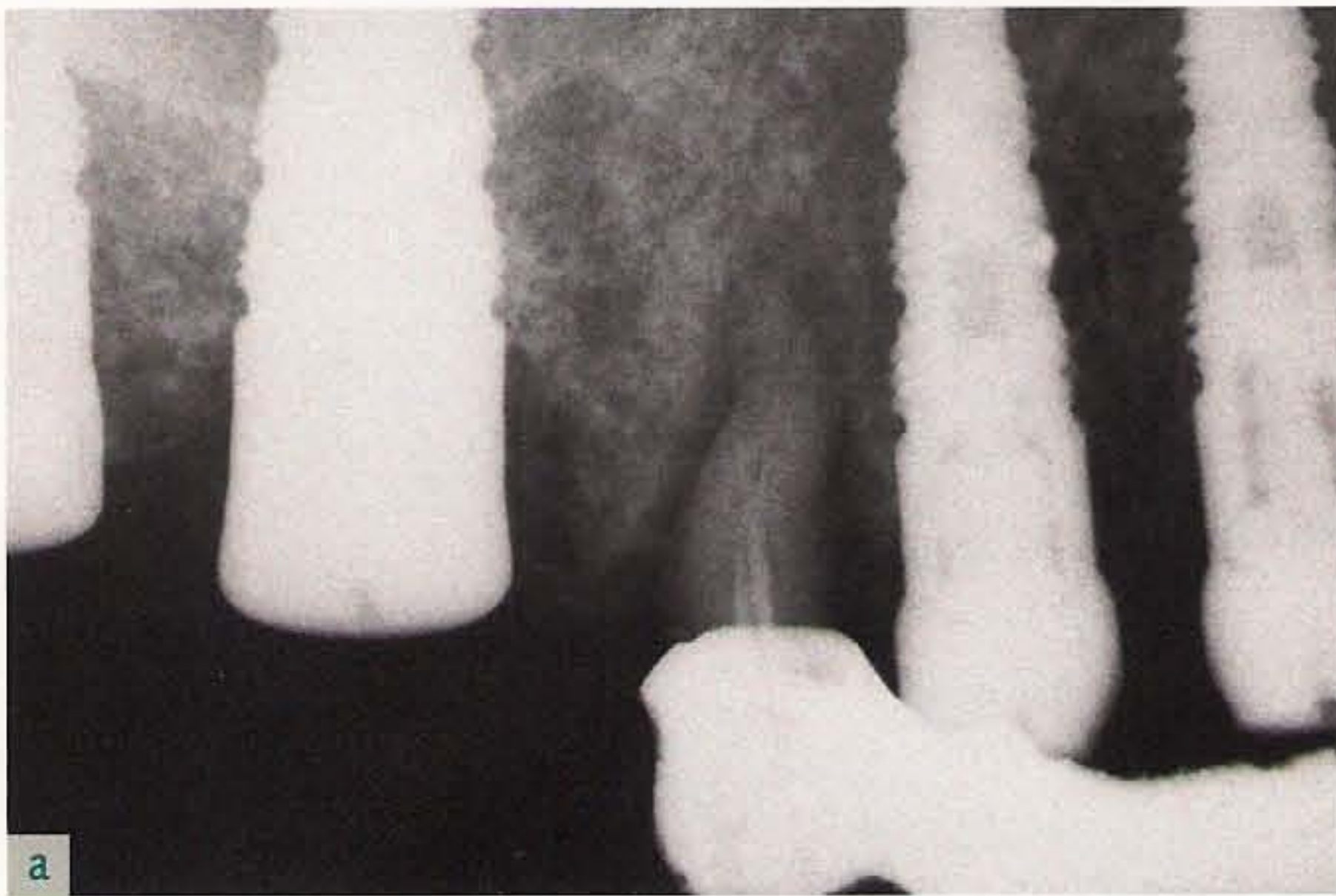


Fig 9-170 (a to d) Radiographs taken at stage 2 surgery reveal optimal healing.



Fig 9-171 Precision impression for the construction of the provisional prosthesis, which is to be anchored to the osseointegrated implant. The impression is taken on the day of the exposure of the implants, to allow early conditioning of the morphology of the peri-implant tissues before cicatrization.

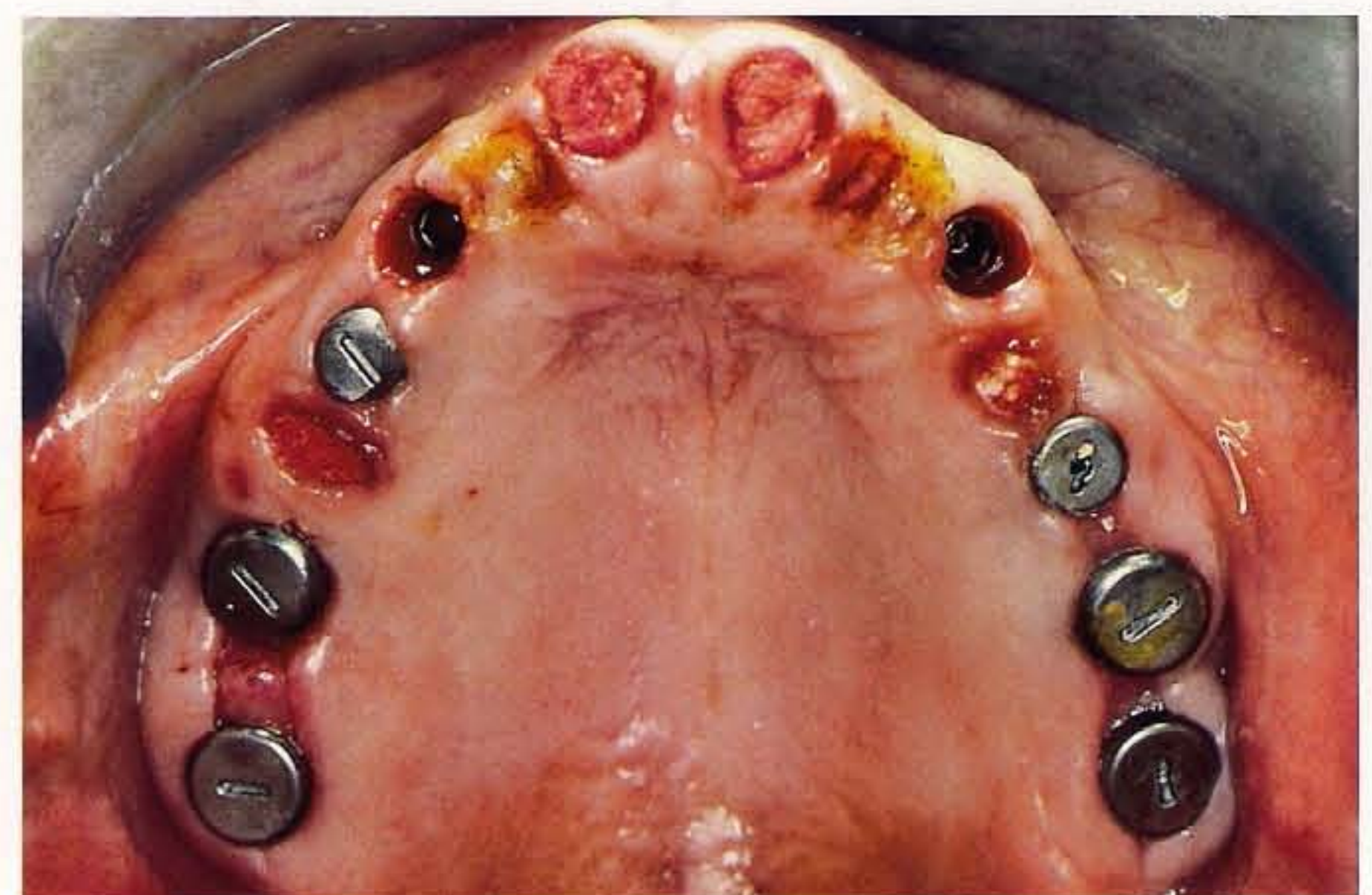


Fig 9-172 After the avulsion of the remaining natural teeth, the alveoli are filled with calcium carbonate and collagen to maintain the morphology of the tooth root. The provisional restoration is then anchored with screws to the osseointegrated implant.



Fig 9-173 The new reinforced provisional prosthesis will affect the conditioning of the peri-implant tissues and the edentulous crest that will receive the intermediate pontics.



Fig 9-174 The maxillary arch is shown after about 4 weeks of tissue conditioning.

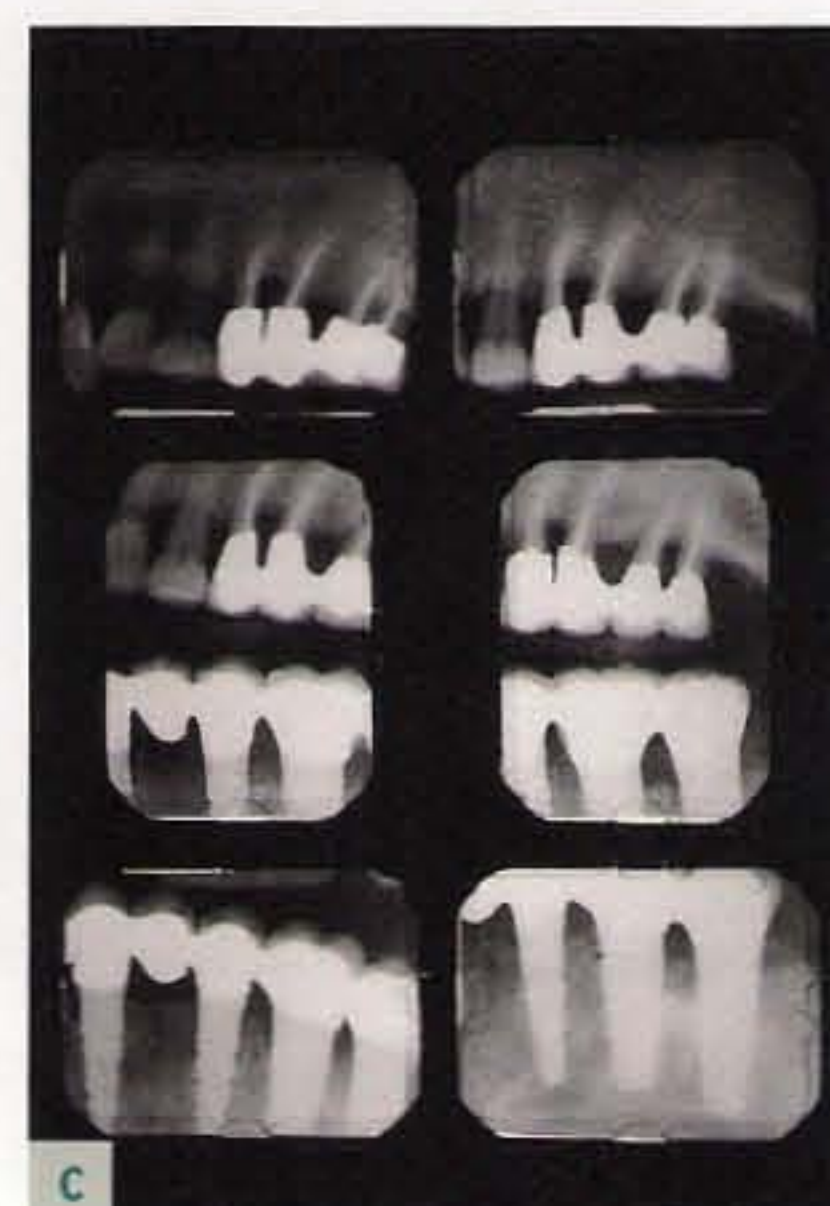
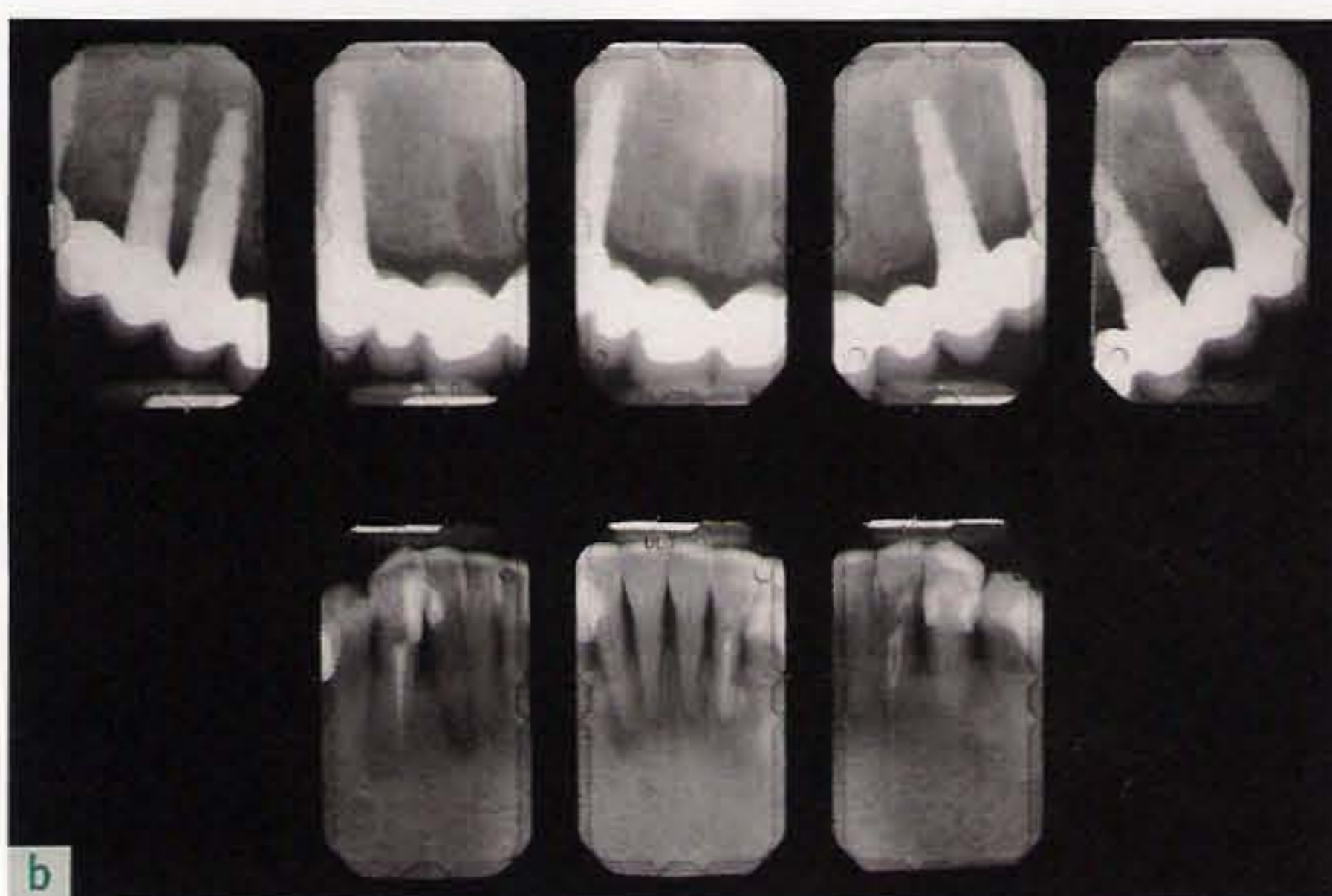
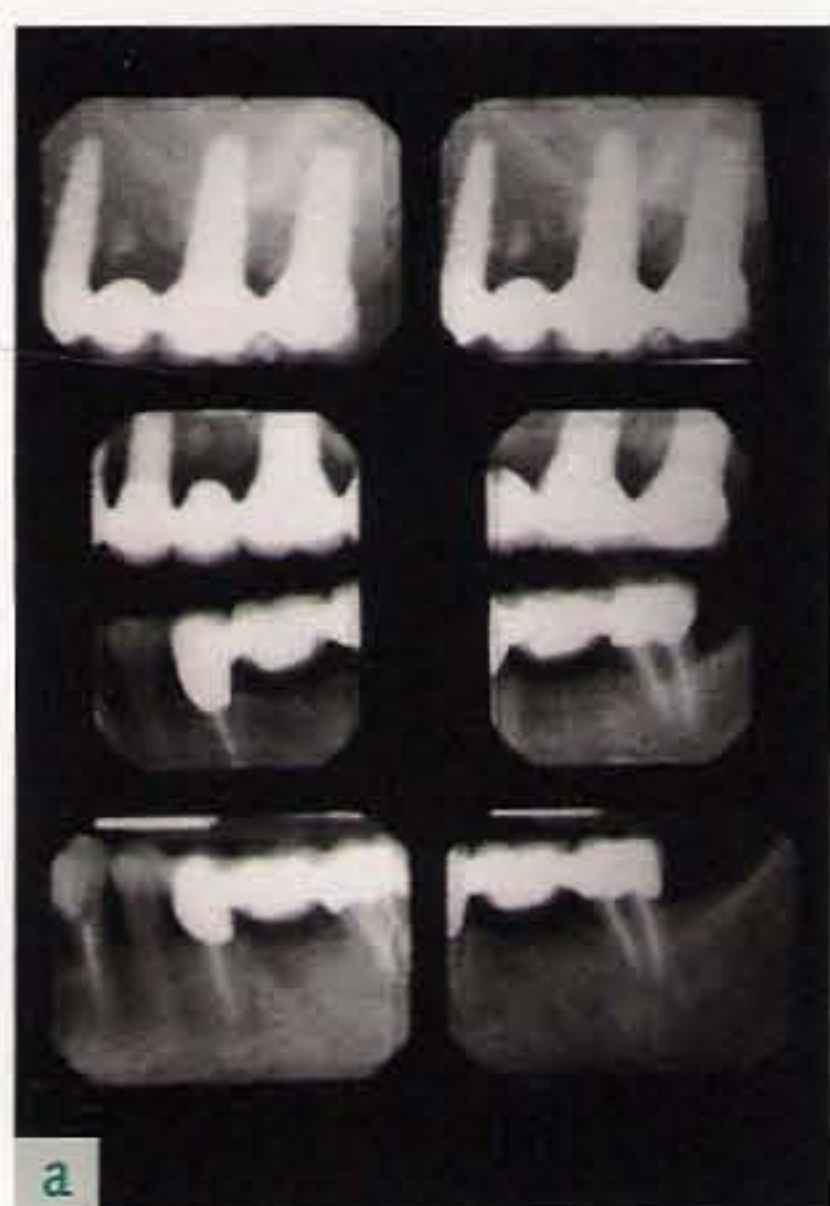


Fig 9-175 (a to c) Intraoral control radiographs of the final prosthesis.



Fig 9-176 (a and b) Frontal clinical views.

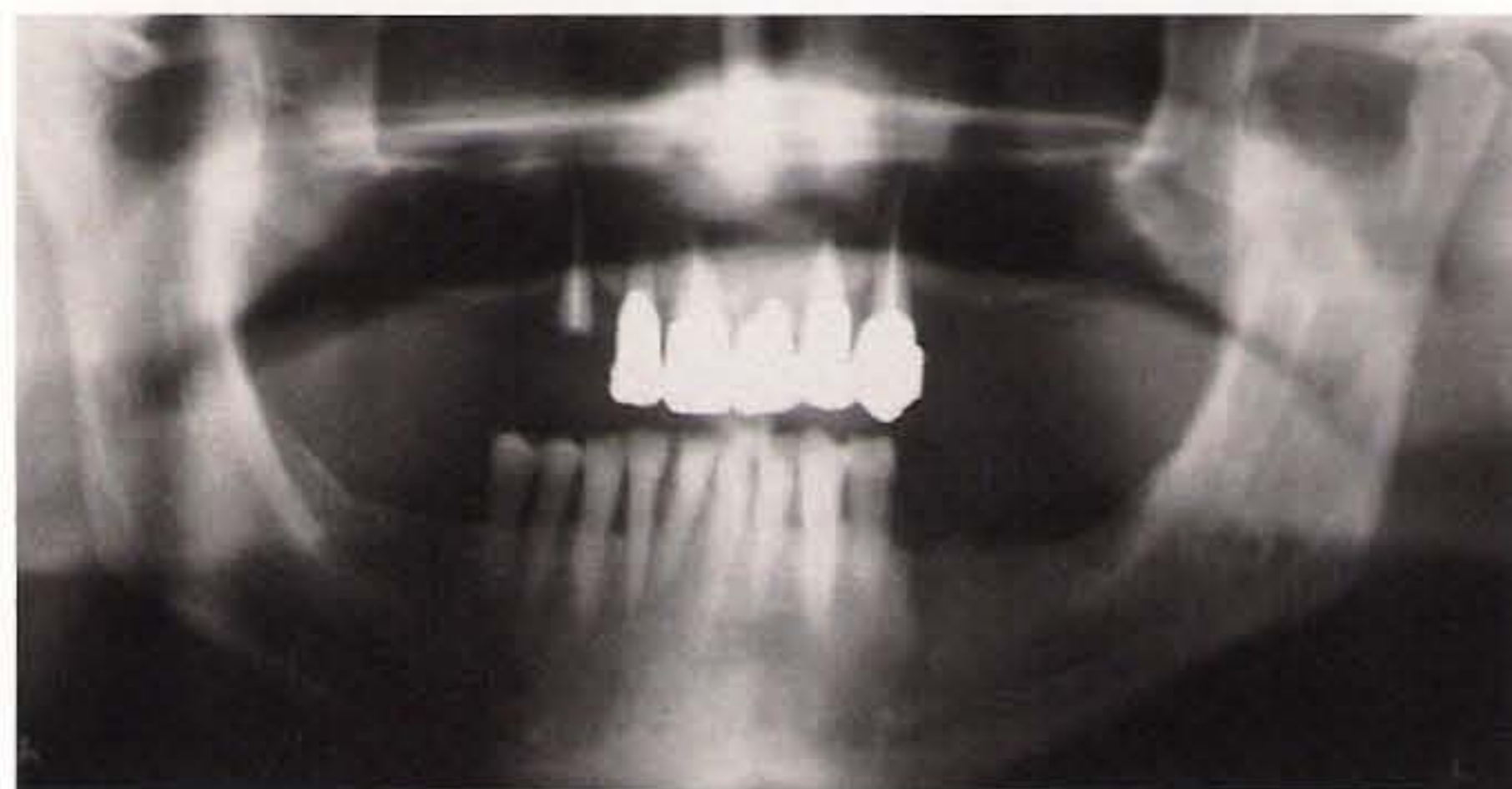


Fig 9-177 Initial panoramic radiograph revealing severe maxillary atrophy. The maxillary teeth must be extracted because they are gravely periodontally compromised.

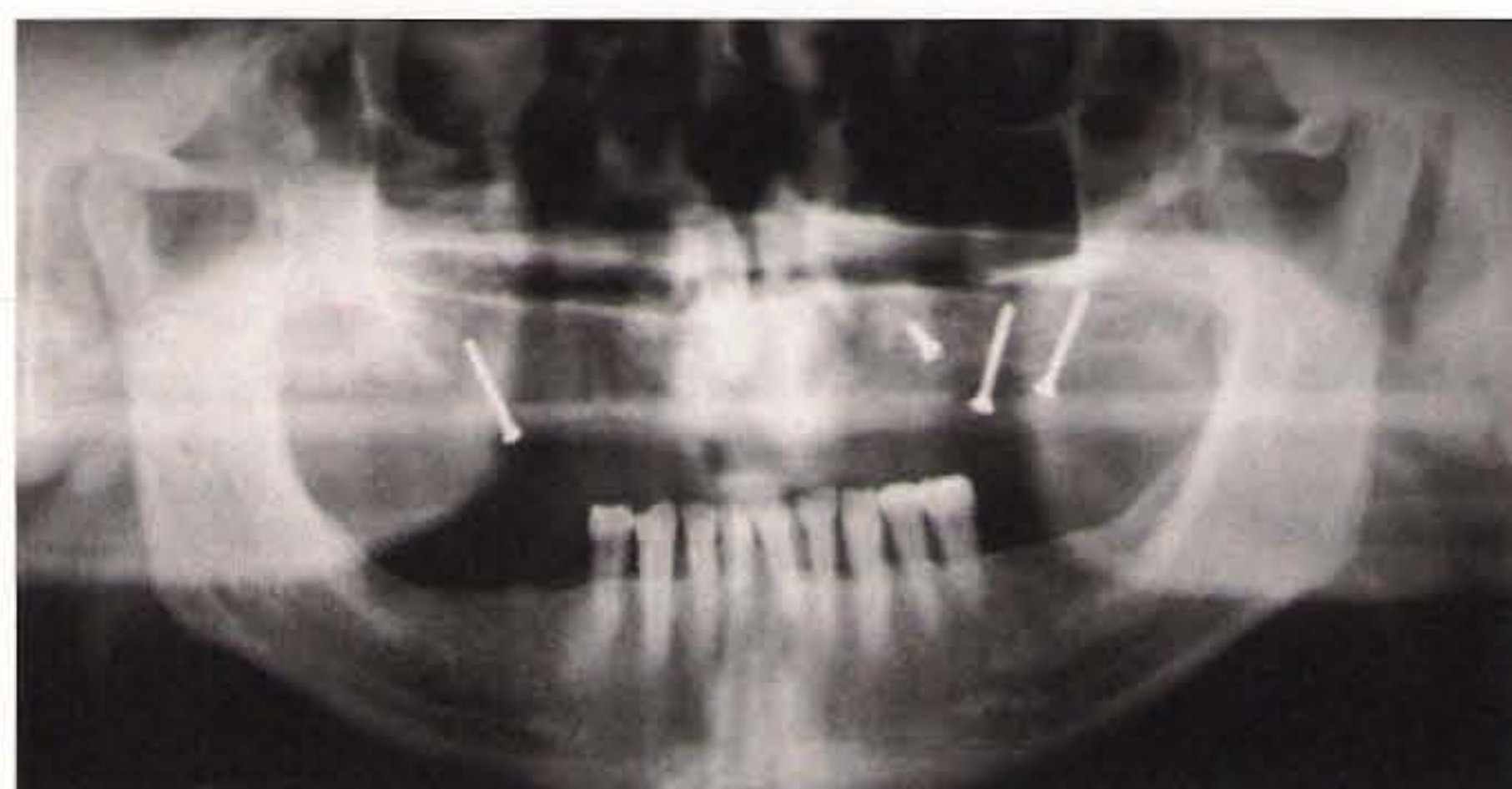


Fig 9-179 Control panoramic radiograph taken after 6 months.

Major surgery

Surgical techniques used for greater amounts of bone augmentation require the patient to undergo recovery in the hospital:

- Elevation of the sinus floor with grafts harvested from extraoral sites
- Onlay bone grafting of the alveolar crest
- Inlay bone grafting combined with Le Fort I osteotomy
- Inlay bone grafting of the atrophic mandible

Elevation of the maxillary sinus with grafts harvested from extraoral sites

In clinical situations involving serious (SA-4-type) osseous bilateral sinus resorption, the quantity of graft material needed is too great for it to be harvested from an intraoral donor site of the patient. The surgical technique is the same as that adopted

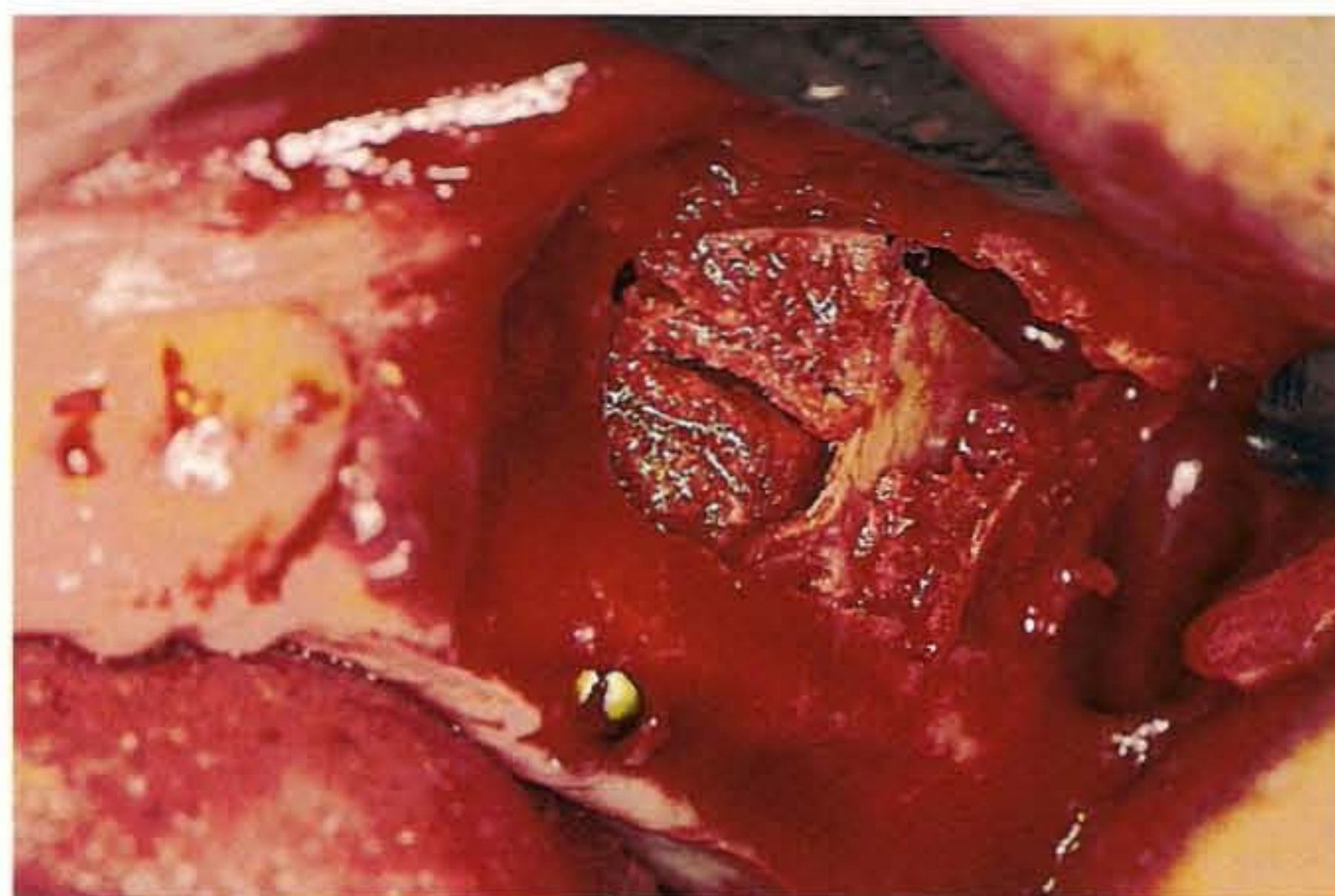


Fig 9-178 A bone block graft taken from the iliac crest is rigidly anchored to the floor of the sinus with titanium screws.

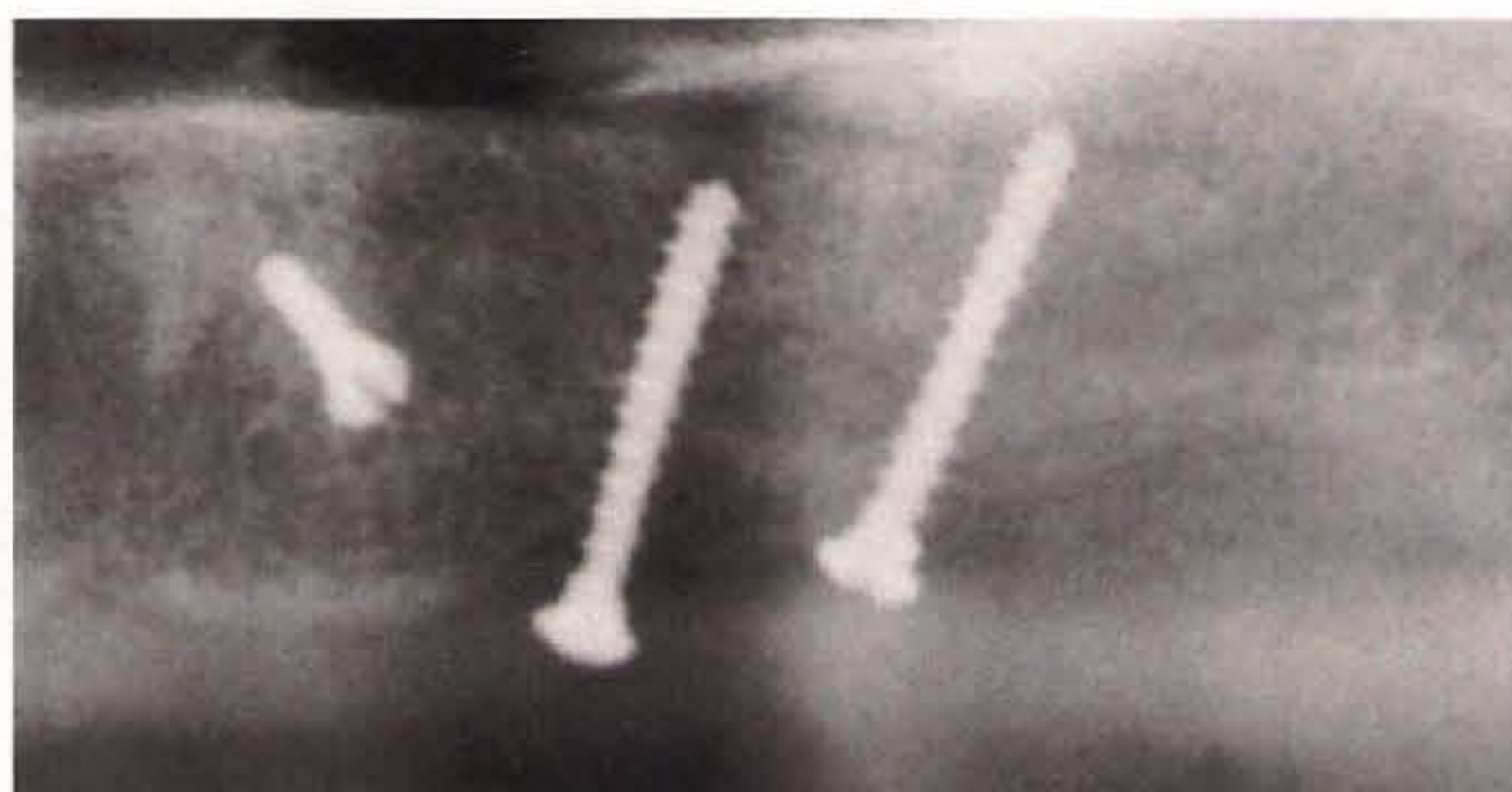


Fig 9-180 Radiograph revealing optimal integration of the grafted bone.

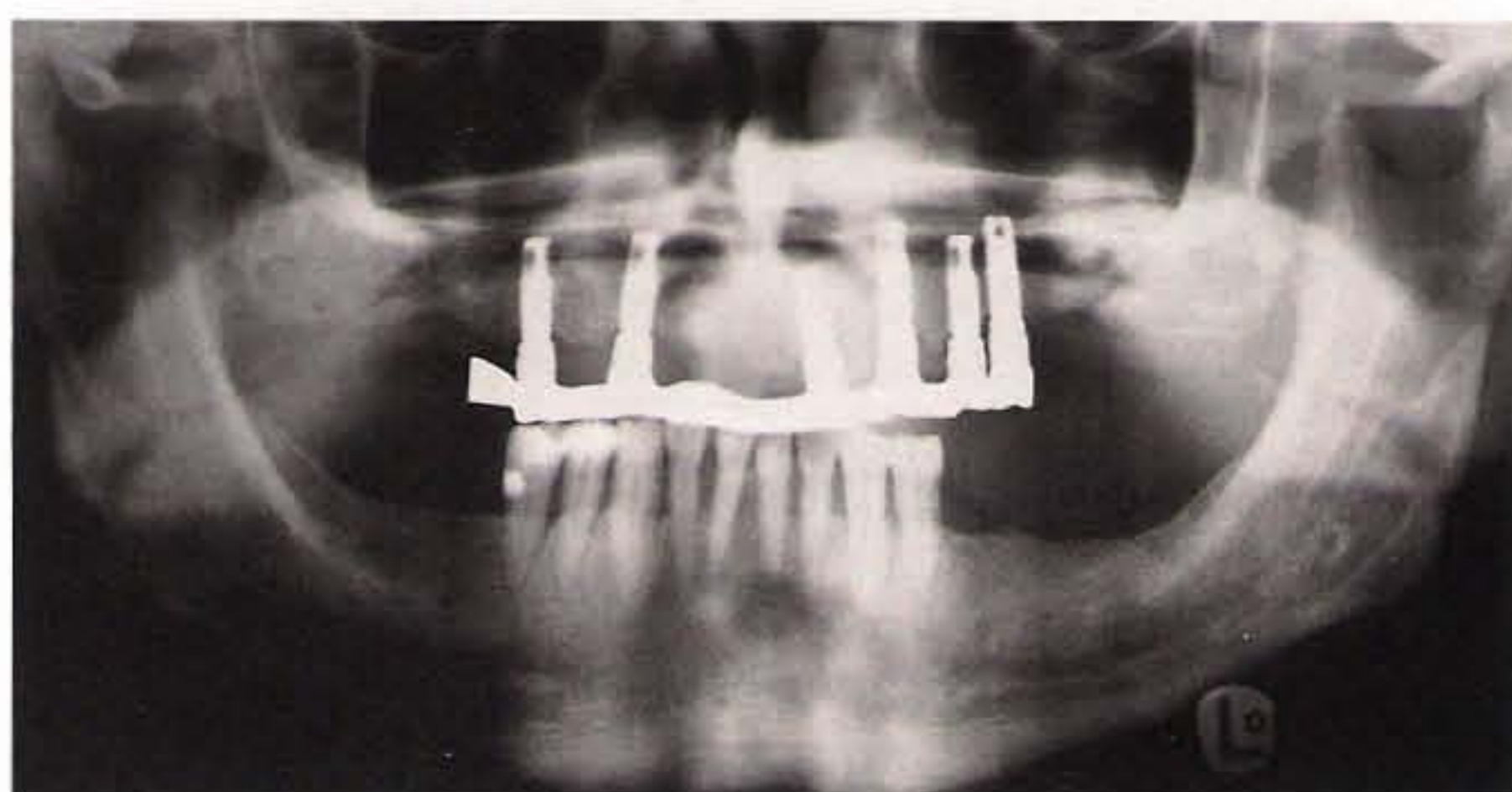


Fig 9-181 Control radiograph of the final prosthesis.

for outpatient procedures of elevating the maxillary sinus; the only change is the technique used for harvesting of the graft, which must be extraoral. The extraoral sites—iliac crest, tibia, cranial theca, or rib—require hospitalization and use of a general anesthesia (Figs 9-177 to 9-181).

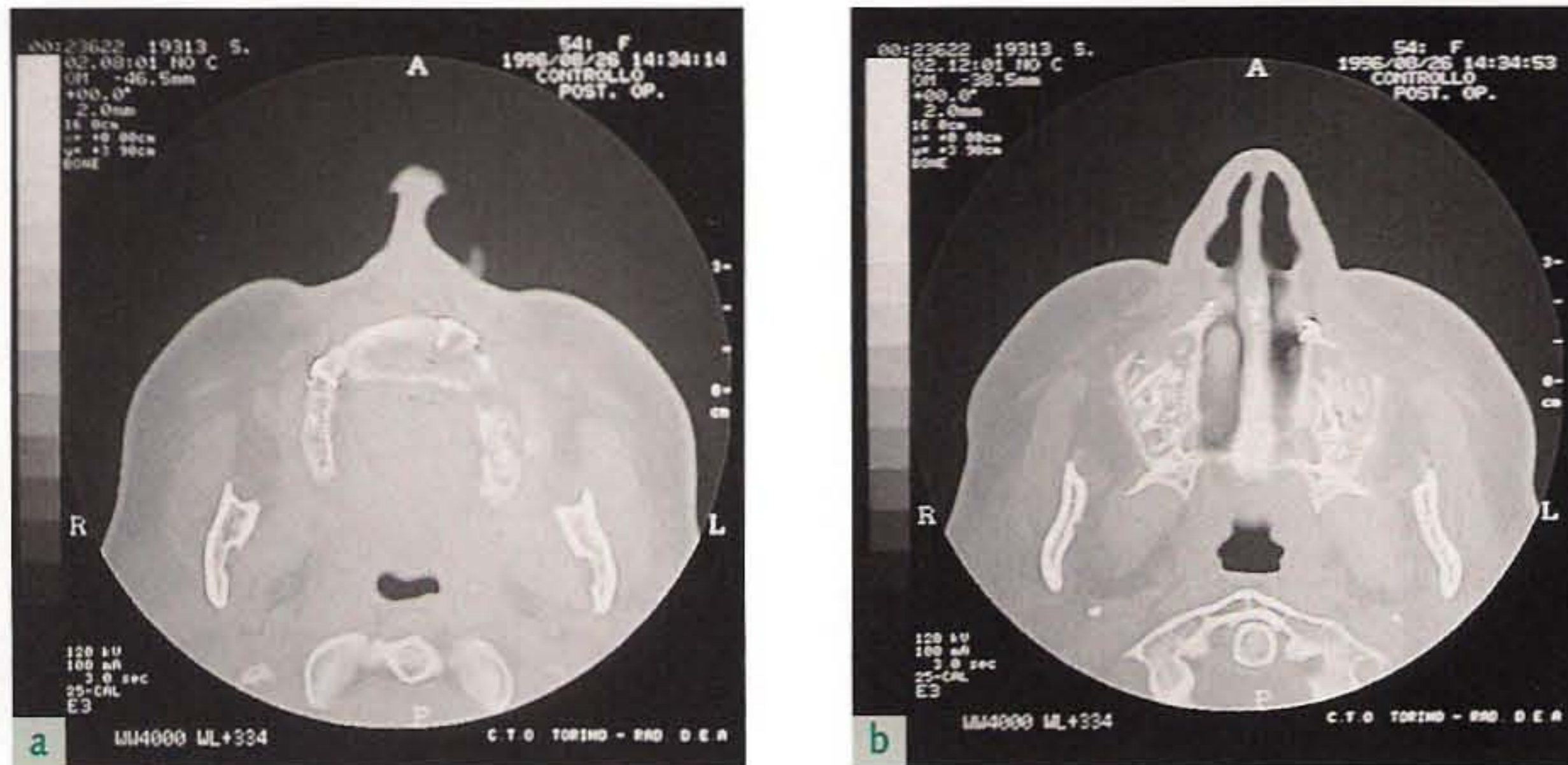


Fig 9-186 Postsurgical CT scans reveal both (a) the well-stabilized anterior onlay and (b) the bilateral sinus elevation with a particulate bone graft taken from the iliac crest.



Fig 9-187 Lateral cephalometric radiograph of the final prosthetic restoration.



Fig 9-188 Frontal view of the completed prosthesis.

tical dimension of the alveolar crest in anterior regions.²⁰⁰ In the distal regions, the inlay technique on the maxillary sinus floor is more advisable.²⁰¹

Inlay bone grafting combined with Le Fort I osteotomy

In 1989, Sailer²⁰² was the first to describe a surgical technique through which the osseous grafts are positioned as an inlay on

the floor of the nasal and sinus cavities, using preventively a Le Fort I osteotomy (total detachment of the maxilla). This method is advised for the treatment of total atrophy in which the floor of the sinus cavities coincides with the profile of the alveolar crest and where a sagittal Angle Class III skeletal discrepancy of the alveolar arch coexists. The technique allows both osseous grafting, as well as the advancement of the superior maxilla (Figs 9-189 to 9-199).

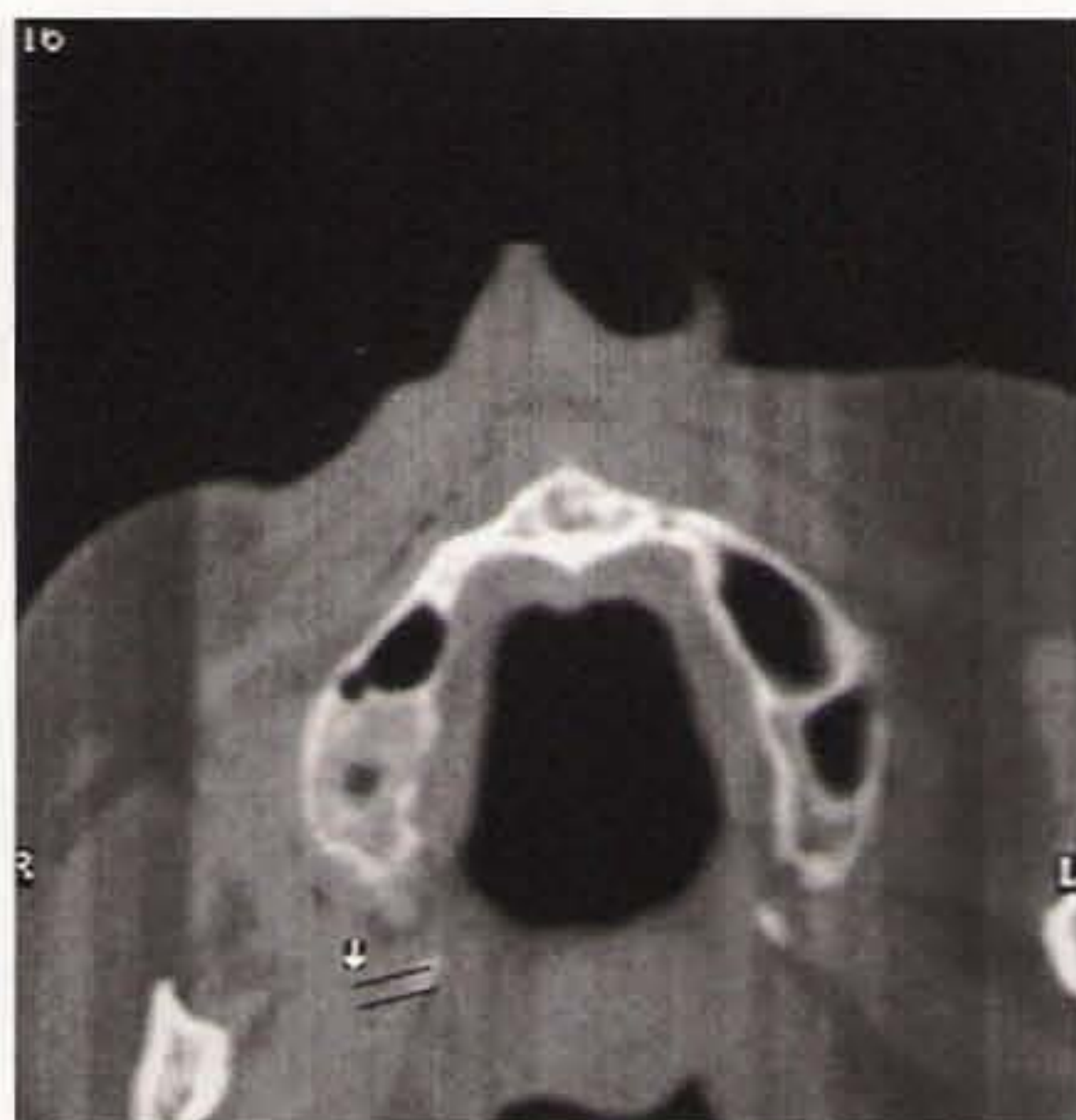


Fig 9-189 The CT scan indicates serious atrophy of the maxilla.

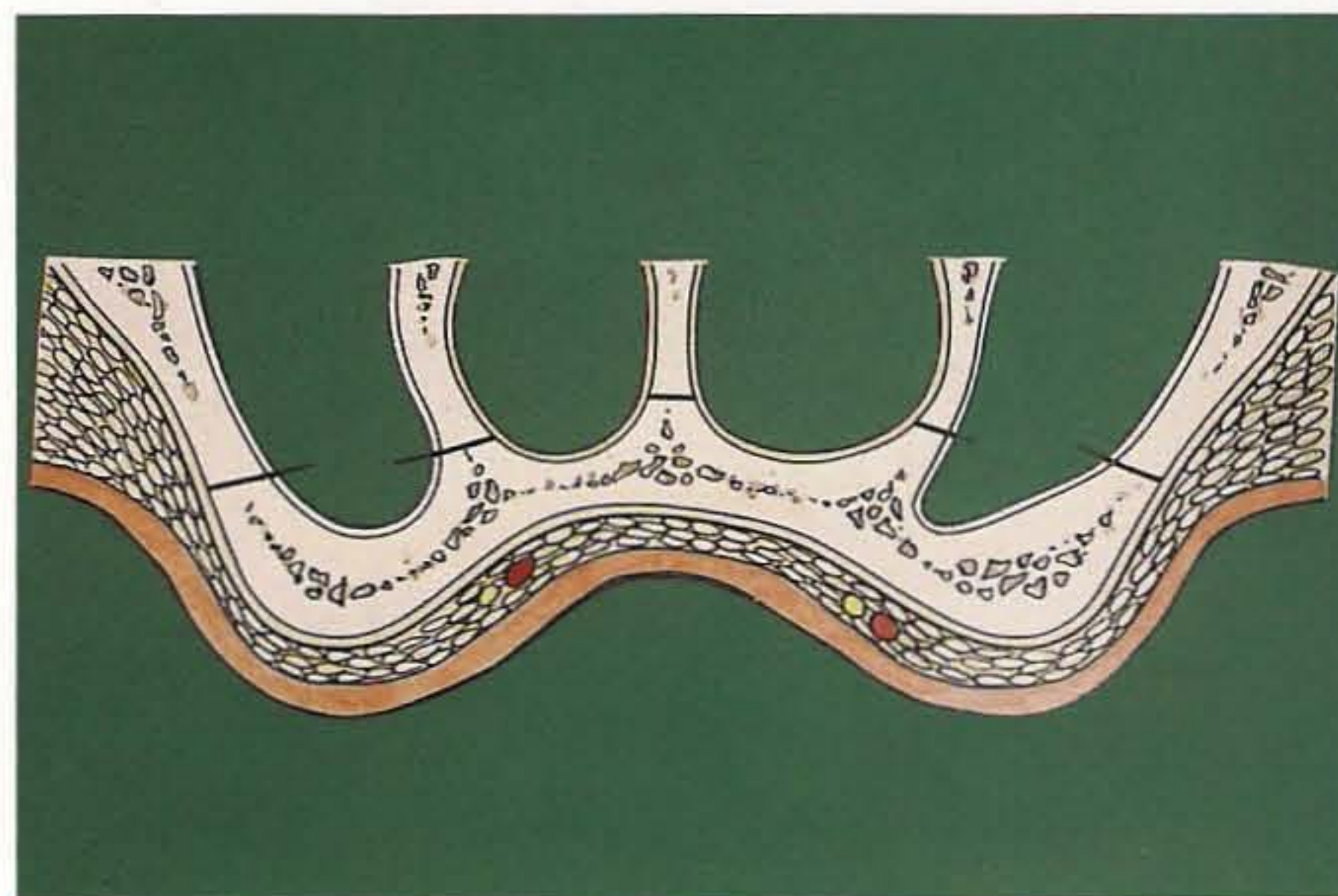


Fig 9-190 Le Fort I osteotomy. (Modified from Härle.²⁰³)

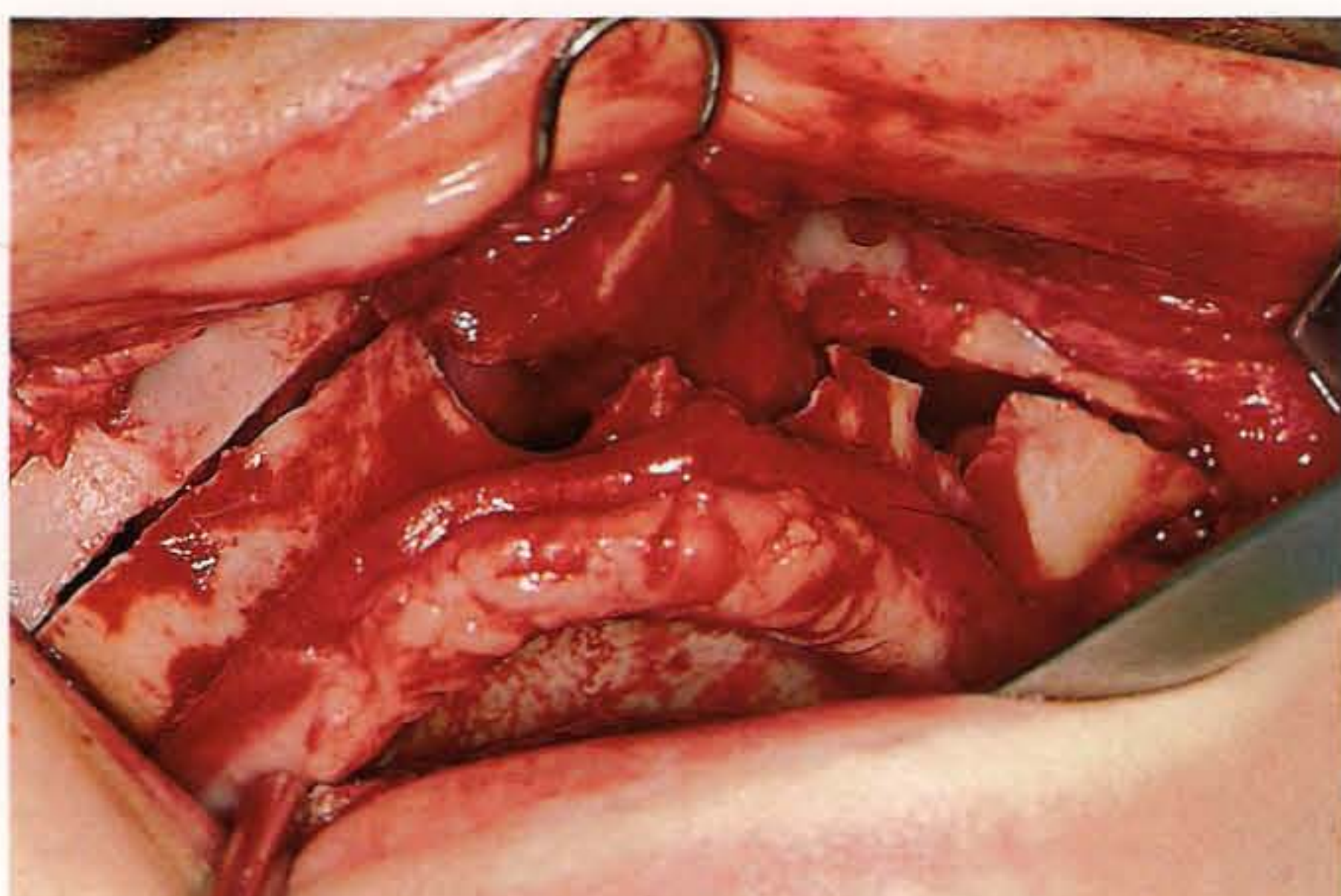


Fig 9-191 Intraoperative view of the maxillary osteotomy.

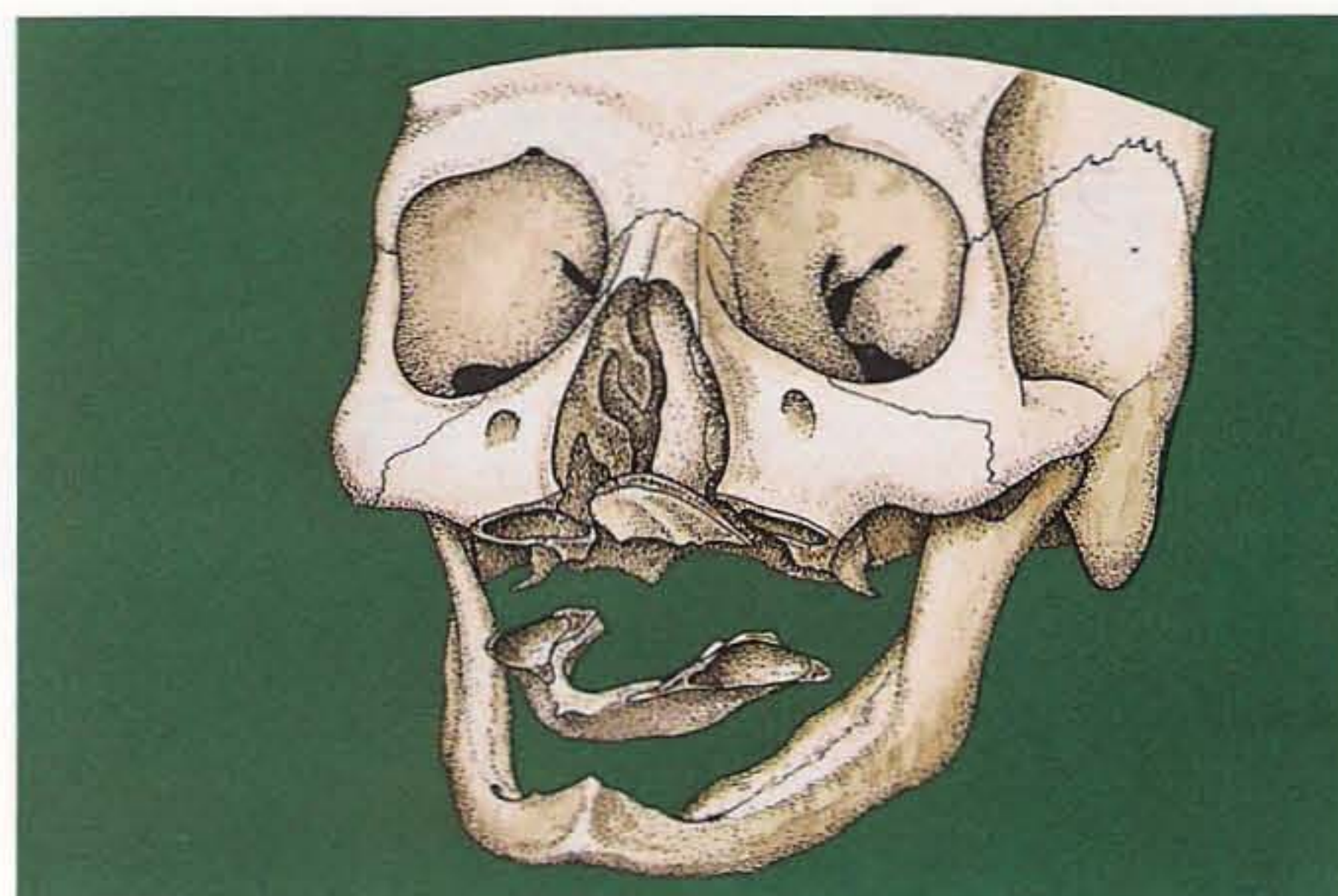


Fig 9-192 Maxillary disjunction. (Modified from Härle.²⁰³)

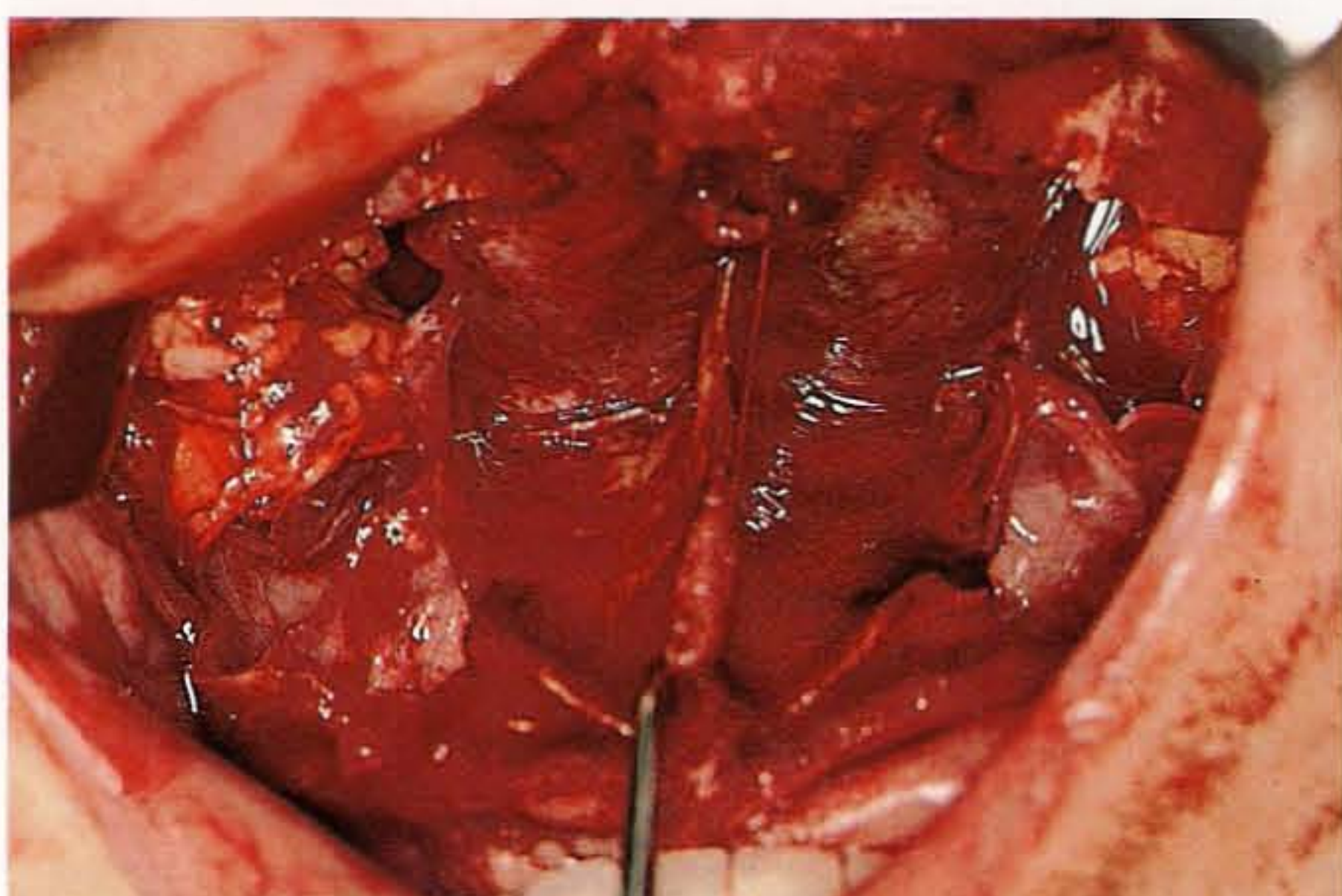


Fig 9-193 Intraoperative view of the maxillary disjunction.



Fig 9-194 Bone graft harvested from the iliac crest.

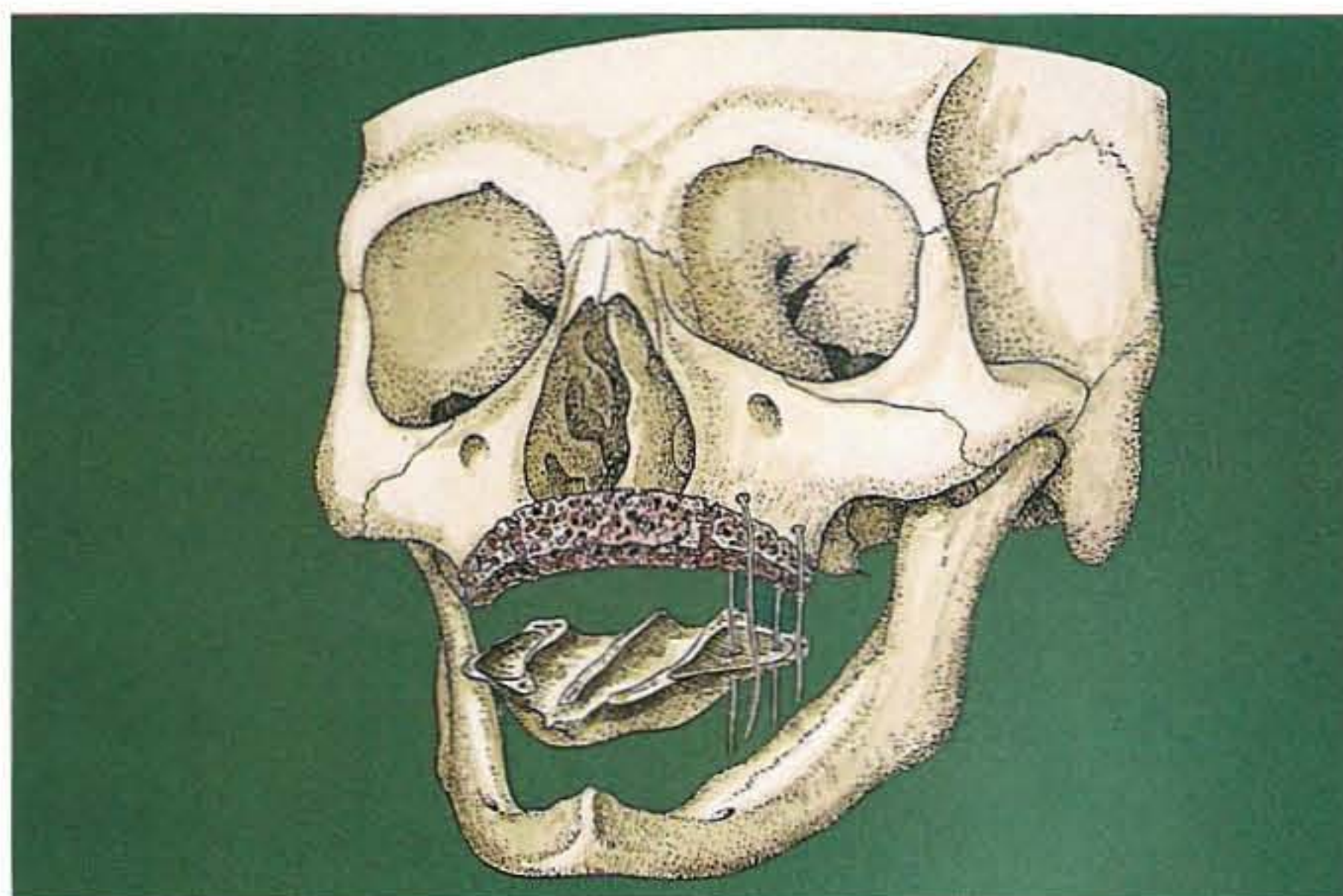


Fig 9-195 Adaptation of the graft to the nasal and sinus floors. (Modified from Härle.²⁰³)



Fig 9-196 Intraoperative view of the individual surgical template that permits the calculation of the correct forward movement of the maxilla.

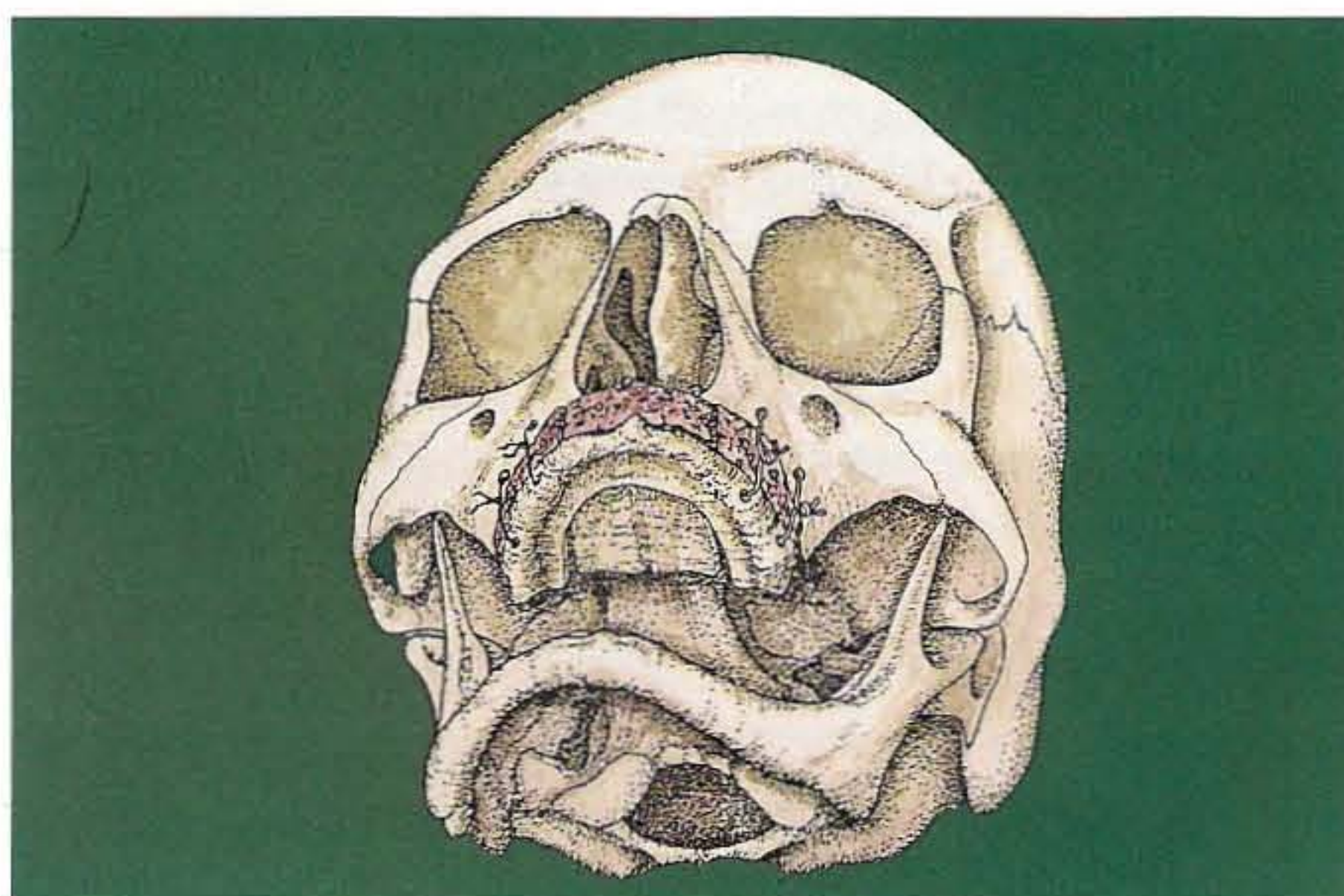


Fig 9-197 Maxillary reinforcement with an inlay graft. (Modified from Härle.²⁰³)

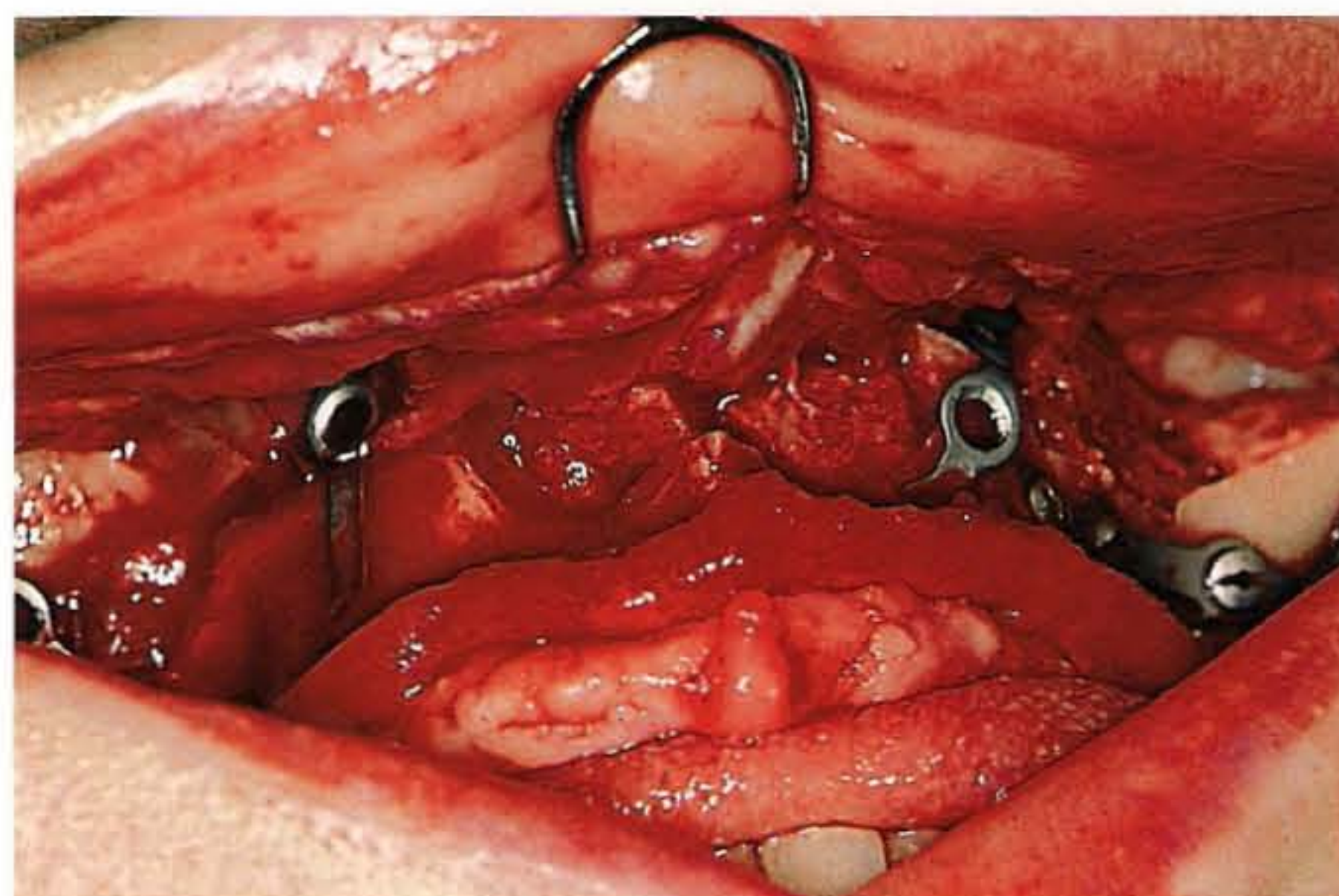


Fig 9-198 Intraoperative view of the inlay graft.



Fig 9-199 Control panoramic radiograph taken after 12 months, with the implant positioned after the removal of the surgical template.



Fig 9-200 Panoramic radiograph of the bone graft taken from the iliac crest, positioned as an inlay after crestal osteotomy above the mental foramen.

The survival of dental implants placed simultaneously with the bone grafts, ranging between 68% and 79%, is more variable than is found with other surgical techniques.^{202,204} If the implants are placed in a second stage, after healing of the graft, the survival of the implants ranges between 80% and 85%.¹⁹⁸

The greatest disadvantages of the technique are linked to the complexity of the surgery. The most common complications are caused by the exposure of the graft with necrosis and ischemia of the tissues²⁰⁵ and by internal hemorrhage and post-operative complications.^{206,207}

Inlay bone grafting of the atrophic mandible

When the level of resorption is so marked that it also reduces the basal bone, the mandible assumes a concave profile, and even the placement of two implants in the intraforaminal region to anchor a complete prosthesis becomes problematic. Indeed, the highest percentage of failure is associated with short implants.²⁰⁸⁻²¹⁰ It is for this reason that the use of 7-mm implants is not advisable. Furthermore, in cases of severe resorption,^{211,212} fracture of the mandible during implant placement^{213,214} is more frequent and very difficult to heal. Triplett²¹⁵ advises a minimum 10-mm height for the mandibular bone in which implants are inserted.

In cases of severe atrophy of the mandible, augmentation of the height of the crest has been proposed,^{216,217} both with alloplastic materials²¹⁸ and with autograft bone harvested from the iliac crest,²¹⁹⁻²²³ tibia,²²⁴ rib,^{225,226} and cranial theca.^{227,228} Onlay grafts²²⁹ require positioning of the graft above the edentulous crest; inlay surgery requires intramandibular interpositioning through a horizontal osteotomy of the mandible. The mandibular onlay was introduced in the 1950s and 1960s by



Fig 9-201 Lateral cephalometric radiograph of the crestal graft, which was positioned as an inlay after the osteotomy below the mental foramen.

Schmid²³⁰ and Obwegeser,^{231,232} and while the immediate result was very good, the graft underwent serious resorption after a short while.^{233,234} To reduce the percentage of resorption of the graft, Härle,²³⁵⁻²³⁸ Schettler,^{239,240} and de Koomen et al^{211,241,242} introduced the inlay technique.

Only with the introduction of implants have the onlay and inlay techniques provided acceptable results.^{243,244} The surgical protocol can be varied according to the possibility of placing the implant at same time as the graft or in a subsequent stage, when integration of the new bone is established. The best results have been obtained through the application of the sandwich-visor technique, conceived and proposed by de Koomen and colleagues.^{211,241,242} The association of implants with sandwich grafts has further increased the predictability and success rate over time of this restoration. In 1988, Albrektsson²¹⁰ published a study of the insertion of 42 implants in patients who had previously been subjected to osseous grafts; the success rate was 97.6%.

Without doubt, in cases of serious mandibular resorption, it is preferable to use surgical techniques involving autogenous bone sandwich grafts harvested from the iliac crest, as in the technique described by de Koomen et al in 1979,²⁴¹ followed by placement of the implants in a second phase, after healing of the osseous graft.

To ensure selection of the most appropriate surgical technique, it is fundamental to identify the emergence of the two mental nerves.¹¹¹ Following osseous resorption, the mental foramina shift toward the peak of the edentulous crest and in some cases can be located on the lingual surface of the mandible.²⁴⁵ The positions of the mental foramina determine the area in which the mandibular osteotomy will be carried out. This area can be, depending on the particular case, above or below the mental foramina (Figs 9-200 and 9-201).

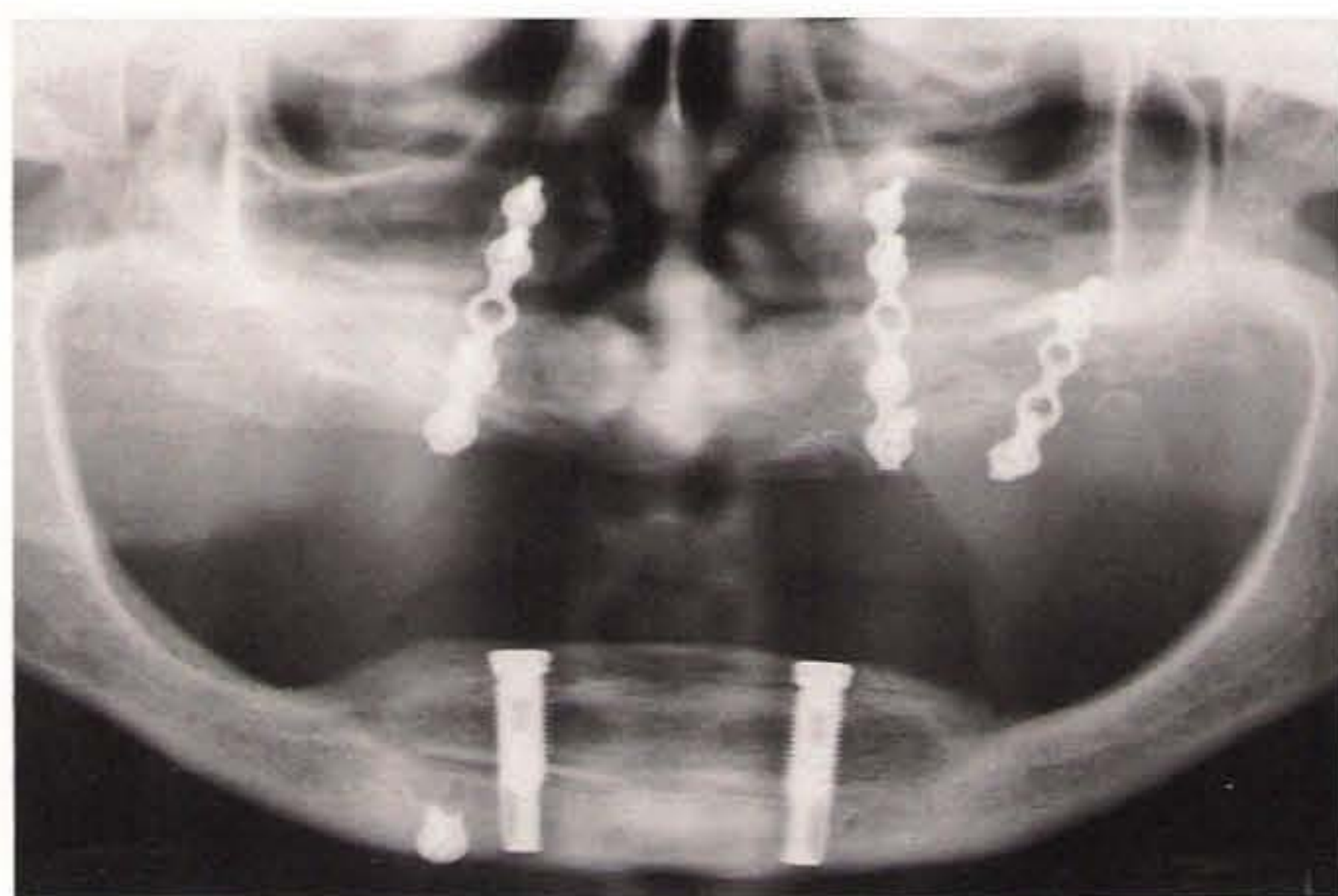


Fig 9-202 Control panoramic radiograph taken after positioning of two Brånemark implants in a case of inlay bone grafting. (Courtesy of Dr Flavio Mela.)

The graft harvested from the iliac crest is stabilized with plates and titanium screws. After healing of the mucosa (about 20 days), a radiographic control is performed to check the positioning of the graft. After 4 months, in an outpatient procedure performed with local anesthesia, the implants are placed following the removal of surgical plates (Figs 9-202 and 9-203). When possible, the sandwich osteotomy technique is always preferred, carried out above the exit of the mental foramina.^{239,240}

Peri-implant Soft Tissue

Another key factor for the maintenance of the osseointegration and for the long-term success of restoration is the integrity of the mucosal seal around the implant and prosthetic components. This integrity is acquired and maintained over time when the process of integration of the implant comes about in the context of healthy soft tissues and in harmony with the residual structures. As with hard tissues, after the connection of the abutment, or at the time of surgery for one-stage implants, soft tissues are always prone to a continuous remodeling and reshaping.

A longitudinal study²⁴⁶ carried out on 63 implants in 11 patients revealed, on a macroscopic level, that 80% of buccal sites, characterized by 98.6% attached gingiva, present recessions of 0.4 mm, on average, in the first 3 months after stage 2 surgery for two-stage implants and after stage 1 surgery for one-stage implants. Based on the current information available, about 1 mm of buccal recession around the implant is predictable in the first year of osseointegration²⁴⁶ (Fig 9-204).

This behavioral trend of the soft tissues around healthy and correctly restored implants has functional and esthetic implica-



Fig 9-203 Radiograph showing details of the positioning of both implants, one in the grafted bone and the other in the basal bone.



Fig 9-204 Buccal recession of 1 mm around an implant. This occurrence is predictable in the first year after osseointegration.

tions of enormous importance. Knowledge of the microscopic and macroscopic differences between architecture of the soft tissues around natural teeth and around implants can be useful in understanding the healing processes, stabilization, and maintenance of the mucosa surrounding implants.

Microscopic aspects

Healing of the peri-implant soft tissues begins with the connection of the abutment at stage 2 surgery in two-stage implants and at the surgical intervention in one-stage implants: Research has clarified how the morphology and the composition of the peri-implant soft tissues contribute to the formation of a mechanical barrier that protects the bone and the osseointegration from physical, chemical, and bacterial aggression originating from the oral cavity.

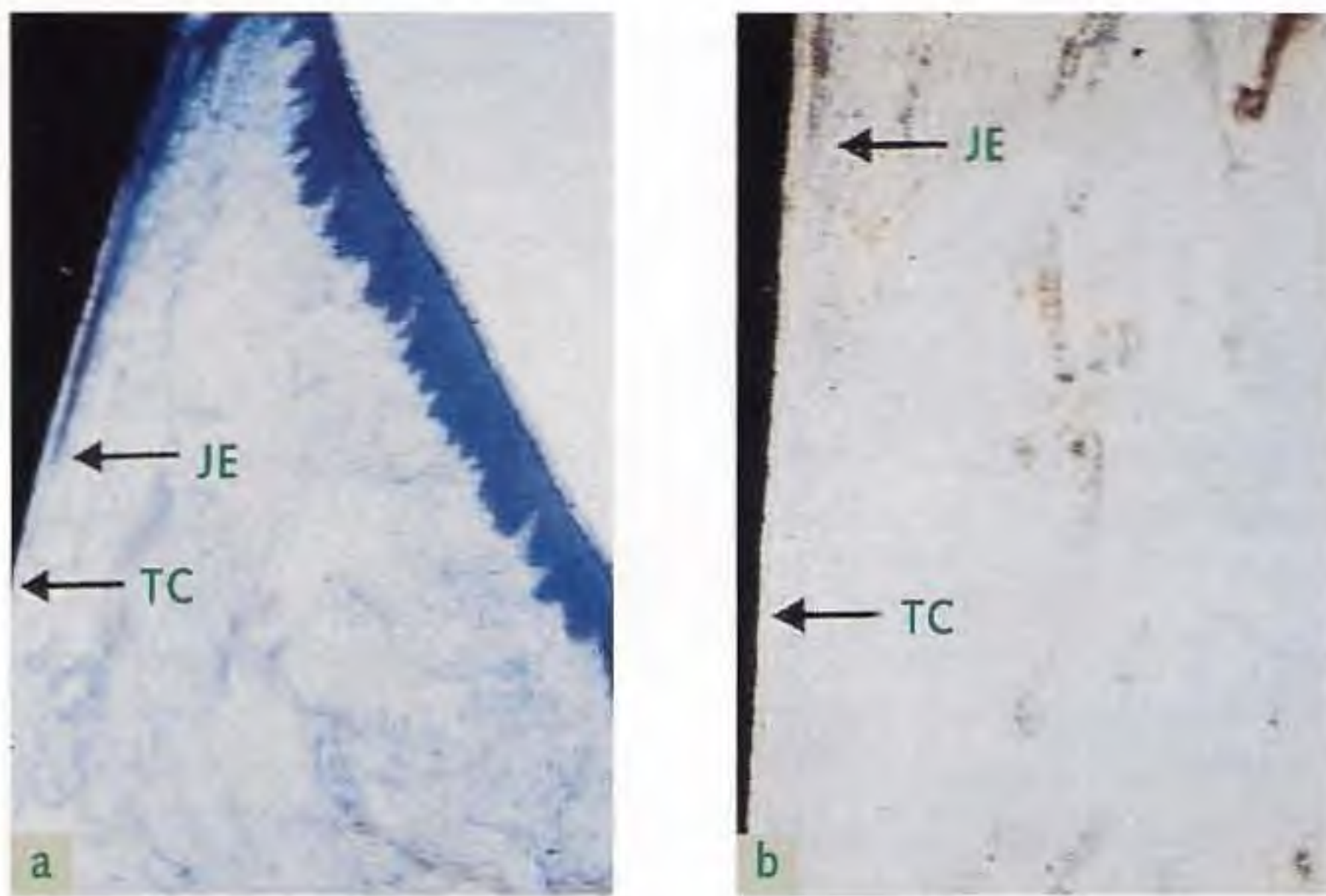


Fig 9-205 Histologic preparation. (a) The mucosal seal around the titanium surface is composed of a junctional epithelium (JE) and one layer of connective tissue (TC) that separates the bone from the oral cavity. (b) Increased magnification of (a). (From Schierano et al.²⁵² Reprinted with permission.)

The mucosa surrounding implants has some characteristics that make it similar to the mucosa that surrounds the tooth²⁴⁷⁻²⁴⁹:

- A free margin and mucosal seal can be seen.
- The mucosal seal around the titanium surface is guaranteed by a junctional epithelium and, proceeding in the coronal direction, by a layer of connective tissue (Fig 9-205).
- The junctional epithelium has a thickness between 1 and 2 mm; it constitutes a barrier that attaches to the titanium surface by means of hemidesmosomes; this characteristic makes it similar to the periodontal junctional epithelium.

A layer of connective tissue separates the junctional epithelium from the bone crest: Various authors agree about some substantial differences between the connective tissue at the implant-mucosal interface (IMI-CT) and the periodontal connective tissue.^{248,250,251} In the periodontium, the collagenous fibers that make up 70% of the connective tissue start from the acellular cementum that covers the root surface: Fibroblasts (20%), blood vessels, and an extracellular matrix are also present. The IMI-CT is wider than the periodontal connective tissue, with a height that varies between 1.5 and 2.0 mm. The collagenous fibers, which start in the extracellular matrix of the IMI-CT, increase in number and in thickness, passing from the portion of connective tissue adjacent to the interface to the more distant portion. Research has individuated collagenous fibers that depart from the crest of the peri-implant bone and within the thickness of the connective tissue, are functionally organized, and are parallel (in an apicocoronal or circular way) to the titanium surface.²⁴⁷ Schierano et al.²⁵² carried out a histologic investigation in rehabilitated patients with mandibular implant-



Fig 9-206 (a) Distribution of collagen fibers around a titanium abutment. (b) Close-up view showing circular fibers (in green), longitudinal fibers (in yellow), and oblique fibers (in blue). (From Schierano et al.²⁵² Reprinted with permission.)

retained overdentures and in patients with a fixed prosthesis on implants, using samples of peri-implant tissue adjacent to the smooth titanium abutment subjected to a functional load for 12 months, to evaluate the organization of the IMI-CT. The analysis of the microscopic specimens showed the presence of collagenous fibers organized in a circular fashion at the connective tissue portion that is furthest from the titanium surface and in a longitudinal fashion in the most interior portion, and oblique fibers that linked the two previous sections to the periosteum of the bone and the submucosa (Fig 9-206). The authors were not able to verify the influence of the different types of prosthetic load on the structural organization and orientation of the collagenous fibers, although they did not exclude the possibility that both the type and duration of the functional load can play important roles in this context.

The majority of studies report the absence of radial fibers perpendicular to the titanium surface. In 1981, nevertheless, Schroeder et al.²⁵³ suggested a direct correlation between the presence of porosity on the surface of the abutment (TPS abutments) and the presence of radial fibers.

Until the middle of the 1990s, different authors emphasized the microstructural characteristics of the IMI-CT, underlining how the more internal area, adjacent to the implant (100 to 200 μ m), was made up of a tissue that was rich in collagen that had few cells, was not very resistant, and had a modest ability to regenerate, remodel, and adapt (reduced turnover), making it comparable to scar tissue.²⁴⁷ In 1996, Abrahamsson et al.²⁵⁴ emphasized that there were no substantial differences in the microstructural characteristics of the peri-implant mucosa of one- and two-stage implants, but the scarcity of cells present in these tissues constituted a substantial difference with respect to

the gingiva. These concepts have today been widely reconsidered.

Recent studies^{251,252} have, in fact, further characterized the IMI-CT, investigating an area of the thickness of 200 μm around the implant and individuating two layers, one nearer the titanium surface and the other further away, with different histologic characteristics. While the more distant area between 40 and 200 μm presents characteristics similar to those described earlier, the connective portion contained within 40 μm adjacent to the implant is instead characterized by a high proportion of fibroblasts (32.2%) and collagen tissue that is poorly represented. According to these authors, it is correct to affirm, given the current knowledge available, that the IMI-CT possesses a high capacity of turnover and that the fibroblasts, which are well represented, can play a determining role in the acquisition and the maintenance of a valid mucosal seal.

More recent research^{255,256,257} has analyzed the biologic mechanisms through which the fibroblasts that populate the IMI-CT are actively involved in the healing process of the soft and hard tissues and in the bone remodeling that accompanies the acquisition and maintenance of osseointegration. The fibroblasts intervene in the processes regarding regulation of inflammation and in the reparative processes of the tissues through interaction with the cellular and molecular components of the extracellular matrix.²⁵⁵ Proteins known as *cytokines*, which function as biologic activators, are also involved in this process. A fundamental role in this process is played by a particular cytokine, transforming growth factor α (TGF- α) and its isoform; this factor is involved in the processes of cellular proliferation, angiogenesis, and the synthesis of extracellular matrix molecules. In vitro research²⁵⁶ has clarified how TGF- α and its isoform, whose local expression grows during implant treatment, promotes the attachment between extracellular matrix molecules and fibroblasts cultivated in the presence of titanium, causing an increase in the local production of adhesion factors. The ease with which the fibroblasts migrate and attach in vitro to the surface of titanium in the presence of TGF- α and the increased capacity to form oriented cellular systems could have a determining influence on the quality of bone healing and healing of the soft tissues around the implants. This would suggest the importance of TGF- α is in the process of cellular attachment to the titanium surface.

The function of fibroblasts is also vital to the process of acquisition and maintenance of the osseointegration.

In adults, the bone quantity is kept constant through the equilibrium of osteoclastic and osteoblastic activity. Many cytokines are involved in the regulation process. Among these, some are involved in a specific way in the growth and development of osteoclasts and osteoblasts, while others function as powerful inhibitors to osteoclastic and osteoblastic activity.

Research carried out in Italy has focused on the processes through which the local production of cytokines influences bone remodeling during healing of the soft tissues after implants in edentulous patients are restored with a mandibular implant-retained overdenture.²⁵⁵ The study demonstrates not only that the insertion of titanium implants induces the soft tissue to produce cytokines that favor the process of integration but also that the gingival tissue participates, via the paracrine system, in the osseous remodeling process around the implants. Among the cytokines that have the capacity of promoting osseous remodeling, TGF- α produced by fibroblasts from the peri-implant mucosa plays a fundamental role in depressing the inflammatory reaction and thereby in promoting the repair of tissue and the osseointegration of the implant. The study again revealed that increase in levels of TGF- α after implant treatment is not confined to the peri-implant site but also involves sites that are sufficiently distant so as not to be conditioned by the diffusion of local factors. The authors suggest that the distribution of the masticatory load to the edentulous distal crests, made more homogenous by the anchoring of the prosthesis to the implants, can promote a cytokine profile that encourages bone formation even at a distance from the implant site.²⁵⁵

Macroscopic aspects

The teeth erupt in harmony with the surrounding tissues. In the natural complement of teeth, health and esthetics are guaranteed by a mucosal seal and by gingiva; these unite to create a profile that closes the interproximal spaces, guaranteeing functionality and esthetics.

Normally, the level of gingival tissue follows the architecture of the bone crest, and, in 85% of cases, the gingival margin is found 3 mm from the bone crest. The width of the gingiva on the buccal side is, on average, less in the mandible than in the maxilla: The maximum width corresponds with the central incisors, while the minimum width is located on the mandibular canines and premolars. Because the bone level follows the cemento-enamel junction, the height of the gingiva in the interproximal portion can vary up to 5 mm. The scalloping is at its maximum in the anterior zone, while it flattens in the posterior segments.

Recently, the dimensions of the gingiva and the mucosa in the different zones of the oral cavity have become a subject of discourse in periodontics and implant dentistry. Müller and Eger²⁵⁸ underlined the importance of two factors for the preservation of a healthy and harmonious relationship between hard and soft tissues in the course of prosthetic restoration on natural teeth and implants. The gingival phenotype, as described by the authors, individuates in the dimensions of the mucosa (thick or thin phenotype), a critical factor for the maintenance of peri-



Fig 9-207 Individual differences in the dimension and thickness of the gingiva (gingival phenotype) are genetically determined and appear to be strictly linked to the form of the teeth. The concept of individual gingival phenotypes in the dimensions of the mucosa is a critical factor in the maintenance of periodontal health; (a) individuals with thin gingival tissues (thin phenotype) are more vulnerable and have buccal recession more often than do (b) individuals with thicker gingival tissues.

odontal health (Fig 9-207): Individuals with thin gingival tissue are more vulnerable and show more frequent buccal recessions. The individual differences in the width and thickness of the gingiva (gingival phenotype) are genetically fixed and appear closely associated to the form of the teeth.

The so-called biologic width, or the distance between the bottom of the sulcus and the alveolar crest, appears to be strictly correlated to the periodontal phenotype. The biologic width hosts, apicocoronally, a layer of about 1 mm of connective tissue and a layer that is equally thick in terms of junctional epithelium; these layers constitute, *de facto*, the mucosal seal around the tooth. It is today universally recognized that the biologic width has the status of a true “organ,” the violation of which constitutes an attack on the health of the tooth: The result is inflammation, destruction of the osseous crest, and migration of the epithelial attachment, all of which result in a gingival recession or in a hyperplastic reaction, depending on the thin or thick gingival phenotype respectively.

These parameters are important when the form and the structure of the natural teeth are altered by any procedure and become critical for the development of a harmonious architecture of the soft tissues around an implant. The implant is, in fact, inserted in an osseous and mucosal architecture that is completely altered (Fig 9-208). After the loss of a tooth, the buccal component is lost in association with the flattening of the interproximal tissues left without bone support: Both the interproximal space between an implant and an adjacent natural tooth and the space between the two implants collapse at a height of 3 mm above the osseous level.

The process of integration of an implant fails without the formation of a mucosal seal. In 1996, Berglundh and Lindhe²⁴⁸

showed that, even in peri-implant tissue without inflammation, an essential requirement for the maintenance of the dimensional stability of the mucosal seal seems to be respected for the biologic width, which the connective tissue needs to structurally organize itself. The authors showed *in vivo* that, where the biologic width is violated, the connective tissue is able to reclaim space, to the detriment of the bone crest. In the *in vivo* experiment carried out by Berglundh and Lindhe,²⁴⁸ the thinning of the crestal mucosa in stage 2 surgery (connection of the abutment) resulted in marked bone resorption and the creation of an angular defect.

In light of such findings, the choice to adopt biologic criteria during the planning of an implant-supported prosthesis would appear to be justifiable:

- A mucous connection with a sufficient minimum dimension (> 3 mm)²⁴⁸ to protect the osseointegration is indispensable around an implant subjected to a load.
- In the healing and maintenance process of the peri-implant tissues, the width and the thickness of the periodontium (gingival or periodontal phenotype) play determinant roles.

Prosthetic aspects

The final objective of all restorations supported by implants is a natural appearance, a critical part of which is the location of soft tissues with respect to the implants or the adjacent natural teeth. The morphology and, as a consequence, the health and the stability of the transmucosal interface are essentially determined at the moment of the three-dimensional positioning of



Fig 9-208 After loss of a tooth, there is resorption of the buccal bone component associated with flattening of the interproximal tissues that remain without bony support.



Fig 9-209 The three-dimensional location of implants can seriously affect the health and stability of the peri-implant tissues.

the implant (Fig 9-209). The only possible correction during treatment is limited to the choice of the abutment.

The implant is characterized by a cylindrical form and by a cervical diameter that rarely corresponds to the diameter of the tooth to be replaced. The placement of the cervical portion of the implant at a depth that is variable in relation to the diameter of the tooth to be replaced has been suggested to exploit the transmucosal route and gradually obtain an emergence profile without undercuts, similar to that of the natural tooth to be replaced.

However, this proposal raises the question of whether the depth of implant placement affects the stability of the peri-implant tissues. In an in vivo study, Hermann et al²⁵⁹ evaluated the location of the implant-mucosa interface on two-component implants (implant and abutment) positioned deeply in the bone. In two-component implants, a space (microgap) exists between implant and abutment; this space varies between 10 and 100 μm , depending on the precision with which the two components in the different systems are managed (Fig 9-210). According to Hermann et al,²⁵⁹ this microgap influences the healing of the peri-implant soft tissues and therefore the eventual location of the implant-mucosa interface: An apical migration of the connective attachment results (restoration of the biologic width), with respect to the abutment-implant interface, in peri-implant bone loss.

Two-component implants can be used with a two- or one-stage technique. In the case of two-stage implants (submerged during the phase of integration and connected, after osseointegration, to an abutment), the histologic and clinical results are similar to those of the one-stage two-component implants (the abutment is positioned in the first clinical phase, and the heal-

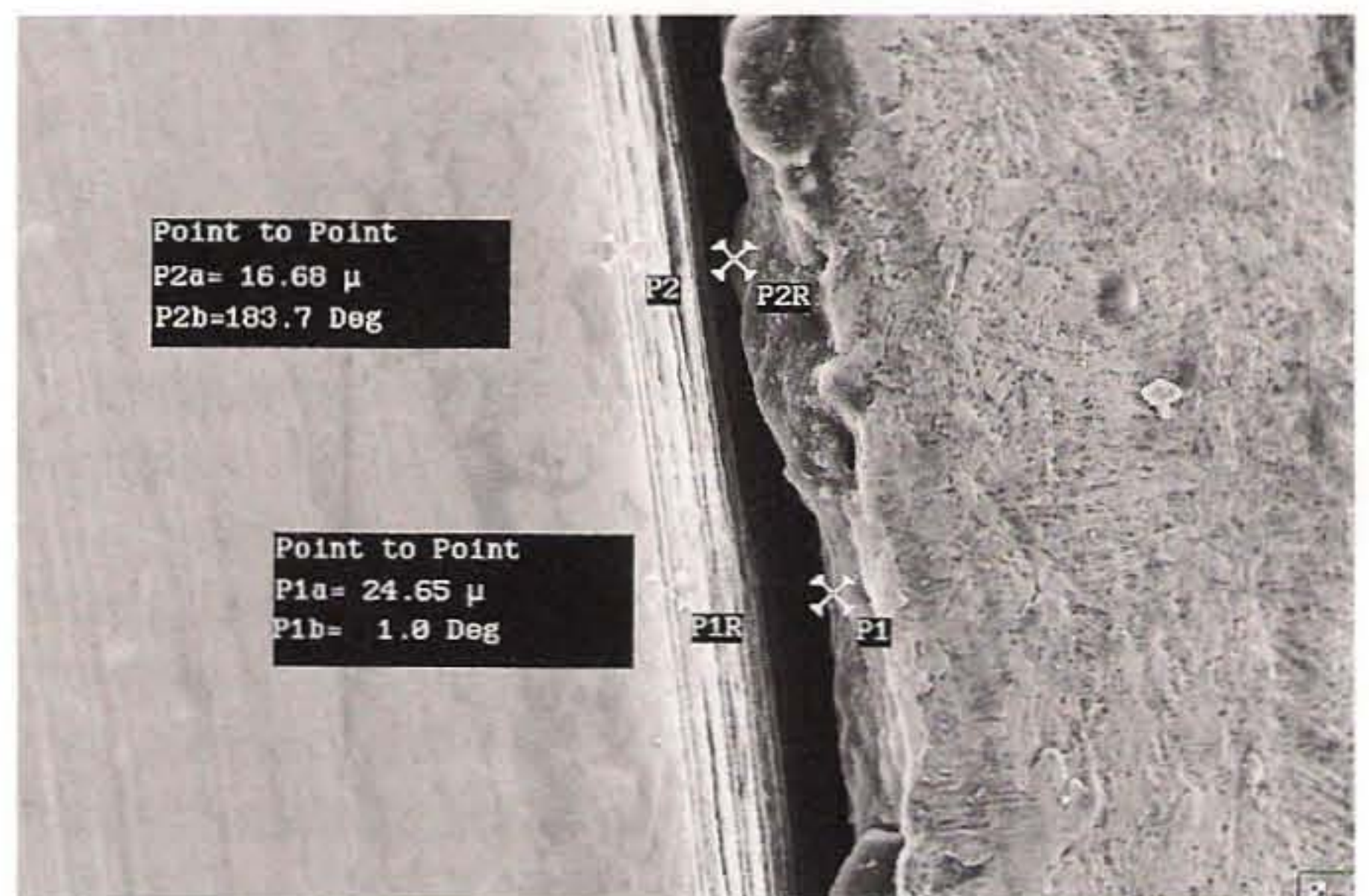


Fig 9-210 Scanning electron microscopic view of the microgap between an abutment and an implant. According to some authors, it is possible that the extent of the peri-implant bone resorption is directly proportional to the width of the microgap. (Courtesy of 3i/BIOMET.)

ing is transmucosal). The process of apical migration starts, however, only after stage 2 surgery, that is, when a microgap is created after the abutment has been connected. This indicates that the position of the microgap between the abutment and the implant influences the healing of the peri-implant soft and hard tissues: The connective seal and the bone migrate apically to the microgap. The deeper the implant is located, the greater the bone loss will be.

The presence of inflammation and resorption related to the microgap between abutment and implant²⁶⁰ has been reported. Todescan et al²⁶¹ found a nonsignificant difference in the degree of bone resorption around implants positioned either



Fig 9-211 In two-component implants, the bone crest is located 1.2 to 1.5 mm apical to the implant-abutment junction (generally at the level of the first spiral thread of the implant). The part of the implant that is coronal to the bone recession then forms a new attachment system (epithelial and connective components).

subcrestally or supracrestally in the presence of a microgap of extremely reduced dimensions between abutments and implants (less than 5 μm).

It seems that a positive correlation between the size of the microgap and peri-implant bone resorption exists. The width of the gap can also increase because of the effect of separation of the components following deformation induced by loading. It is therefore essential to have available a range of precise abutment sizes that can mesh precisely with implants, are resistant to deformation and rotation caused by loading, and can guarantee maintenance of the microgap below the critical values.

The bone crest is located 1.2 to 1.5 mm apical to the implant-abutment interface (Fig 9-211). It would seem obvious that, when esthetics is not an issue, it is advisable to position the implant slightly supracrestal to reduce peri-implant bone loss. If the implant has been positioned at or apical to the level of the bone crest, gingival recession is predictable, as is formation of a new mucosal seal in a more apical position. The prosthetic treatment therefore requires a phase of provisional restoration on the final abutments to guarantee the acquisition and maintenance of a correct morphology of the peri-implant tissues. If instead, the implant is positioned coronally with respect to the bone crest in such a way that the formation of an implant attachment can be immediately obtained, the morphology remains stable during the prosthetic maneuver, with reduced esthetic alterations over time.

The unscrewing of the abutment brings about the mechanical destruction of the attachment between the implant and soft tissue and the reestablishment of a new attachment, which, in terms of the biologic width, is located apical to the implant-

abutment interface.²⁶² This brings about peri-implant bone recession at the level of the first thread in screw implants. The part of the implant coronal to the bone recession hosts a new system of attachment.

To reduce the need for screwing and unscrewing of the components, it is possible to:

- Adopt an alternative prosthetic technique that consists of preparing a definitive abutment before the stage 2 surgery by means of an impression taken during the positioning of the implant. This abutment is directly positioned during stage 2.
- Position the final abutment at stage 2 and prepare it in situ.
- Immediately position an abutment for screw-retained prostheses.

These three techniques avoid the use of the healing abutment.

It has been shown that the material used for the construction of the abutment influences the quality of the mucosal attachment. Abrahamsson et al²⁶³ evaluated the possibility of attachment on abutments of differing materials. The formation of an attachment was examined in the presence of a titanium or an aluminum oxide abutment positioned during stage 2 surgery. The titanium abutments were packaged by the manufacturer in sterile packages, and a sterile technique was used. In the presence of other materials, the authors found gingival and bone recession and formation of the connective attachment directly on the implant. On the titanium and ceramic implants, an inflammatory infiltrate in the mucosa was present in correspondence with the implant-abutment interface; this infiltrate constituted, according to the authors, the reaction to bacterial contamination through the internal portion of the abutment and the microgap.²⁶³

In past years, the weak point of prosthetic treatment was to be found in the mechanical stability of the connections among implant, abutment, and prosthesis. In recent years, enormous progress has been made in this aspect:

- The mechanical precision of the components has increased considerably, and working tolerances have been reduced to a minimum.
- The connection mechanism of the different components have been revisited from a mechanical point of view, and the tightening techniques have been improved.

The first consequence was that the use of screw-retained prostheses in fixed restorations on implants was reduced as a result of the cementation technique, which is faster in prosthetic procedures and simpler for the operator because it is similar to the treatment used on natural teeth.

All types of abutments can be used with success, but the key to maintaining lasting esthetic results is to evaluate the clinical

situation each time and to select a transmucosal component that is simple, precise, and economic. The reconstructive procedures must be simple and precise, to reduce the length of treatment and therefore the number of appointments and trips to the laboratory.

If the healing abutment was positioned at the first surgical stage, macroscopic alterations of the peri-implant tissues do not occur, and the provisional prosthesis can be in position for just a short time. When the healing abutment or a definitive abutment is positioned at stage 2 surgery, it is necessary to resort to provisional restoration for longer periods. The provisional prosthesis and therefore the abutment preparation should respect a harmonious root profile in such a way as to support the soft tissues and create a correct emergence profile.

When the soft tissues have adapted themselves to the morphology conditioned by means of the provisional prosthesis, the pick-up impression of the metal framework is taken. An elastomeric impression of the provisional restoration is also taken to use as a template of the emergence profile of the final restoration.

Immediate Loading: What Is the Future?

Two-stage surgery, as proposed by Brånemark and collaborators in the mid 1960s, involves an implant-prosthetic restoration protocol with great predictable success.²⁵⁸ Nevertheless, in the last 10 years,²⁶⁴⁻²⁷² new protocols have been developed, with the aim of accelerating the period of restoration and also offering undeniable advantages to the patients. In the one-stage protocol (one-stage with delayed, early, or immediate loading), only one surgical operation is necessary and the waiting period is reduced. For one-stage implants with immediate loading, the condition of edentulism in the patient can be reduced to less than a day after the insertion of the implant.

Clinical aspects

The terminology used in this field has often created confusion: *Immediate loading* indicates the possibility of establishing occlusal contacts the same day, or at most within a few days from the implants insertion; *early loading* means establishing occlusal contacts within 1 or 2 weeks;²⁷³ and *delayed loading* means a period of 4 to 6 weeks²⁷⁴ before the insertion of the prosthesis. These different protocols are probably justifiable when associated with different histologic and biomechanical situations, and further research is needed to justify these distinctions.²⁷⁵

Even if, at least in the intraforaminal region, smooth-surface implants have allowed the use of the immediate-loading protocol with predictable results, in the majority of protocols for immediate loading and especially in the maxilla, the use of implants with rough surfaces that favor a more rapid osseointegration is considered more appropriate.²⁷⁶

Immediate loading of fixed prostheses in the edentulous mandible, with implants inserted in the intraforaminal region, has been shown to be a treatment with higher predictability, almost like the two-stage technique.²⁷⁷⁻²⁷⁸ In the edentulous maxilla, the number of cases analyzed relative to immediate loading appears to be greatly limited and therefore insufficient to confirm the protocol. For the moment, on the basis of the little clinical information available, scientific evidence^{269,272,273,279} clearly advises the application of the protocol for the immediate loading only in the mandible.

Thanks to the continuous development of biotechnologies, the immediate-loading approach, will certainly, in the future, also be applied in the treatment of totally edentulous maxilla. A recent clinical study, published by van Steenberghe and collaborators,²⁸⁰ demonstrated the possibility of treating patients who have completely edentulous maxillas with a fixed definitive prosthesis delivered at the end of implant surgery. This restoration procedure through implants is based on information technology developed in Leuven (Leuven Information Technology based Oral Rehabilitation by means of IMplants [LITORIM]). A precise treatment plan is possible because of the evolution of three-dimensional software, which allows the creation of three-dimensional casts on which it is possible to construct precise surgical templates and the prior fabrication of a fixed rigid prosthesis. It involves an extremely customized approach with the advantage of being able to optimize esthetics and phonetics. Unlike the Brånemark Novum system (Nobel Biocare),²⁷¹ in which both the surgical hardware and the prosthetic hardware are premanufactured in a standard manner, this procedure uses premanufactured hardware customized for individual patients.

Therefore, it is possible to attempt immediate loading in cases of complete and partial edentulism or single-tooth edentulism in any area of the maxilla. The best prognosis is when the prosthetic restoration with immediate loading allows the rigid connection of more implants placed in good quality bone. The main risks involve restorations with single crowns or small fixed partial dentures on implants placed in the posterior maxillary region, where a greater functional load and a poor quality, low-density bone exist. Usually, a patient's request for immediate tooth replacement is dictated by esthetic rather than functional needs. By avoiding the zones that are most at risk, which are moreover often not in clearly visible esthetic positions, and informing the patient of the greater objective risk of failure compared to the normal approach with delayed loading, the cli-

nician may obtain a considerable degree of cooperation in the first 6 to 8 weeks after surgery, which is the period that is most at risk in terms of success of the restoration with immediate loading.

Experimental aspects

Osseointegrated implantation has stimulated researchers to understand the healing processes of the bone in its most intimate mechanisms, with the aim of shortening the waiting period between the placement of the implants and their functional loading.

In the field of research, tissue engineering applied to osseointegration follows, still on an experimental level, the following therapeutic strategies:

- Structural therapy
- Cellular therapy
- Genetic/peptidic therapy

Structural therapy attempts the optimization of topography and chemistry of the implant surfaces. The rough titanium surfaces favor "secondary stability," which is determined by the reaction of bone tissue to surgical injury and to the surface characteristics of the implant.²⁸¹ This reaction accelerates the initial healing phase through the absorption of protein and the retention of fibrin. Furthermore, it has been demonstrated that a thicker layer of titanium oxide favors the differentiation of the progenitor cells in mature osteoblasts, which lead to osteoid expression and to subsequent mineralization, with an increase in the retention and stability of the implant.²⁸²

The chemistry of the surfaces of the implant can be bettered through the application of HA, which favors osseointegration. Chemat Technology, in collaboration with the University of California, Los Angeles, School of Dentistry, has developed a new procedure for deposition of HA on the surfaces of the implants. This process involves application of a new nanotechnology, HA nanocoating, which avoids the problems of coating detachment that have arisen in the past.²⁸³ This enables electrostatic self-assembly of a multilayer of 100 nm of stable HA: The crosscut tape test (100 nm) has reached the value of 0% material detached. The experimental hypothesis is that the implant coated in HA can stimulate the expression of some genes involved in the osseointegration process and therefore make it quicker.

Cellular therapy involves changing the cellular population in the bone around the implant. The implant can be associated with stem cells, which are able to go to osteoblastic differentiation and produce bone tissue, essentially performing a "transplant." These cells can come from embryonic tissue or from adult tissue, from bone marrow to adipose tissue,²⁸⁴ even from

the same receiving individual. The well-noted ethical problems in terms of embryonic cells and in terms of checking for eventual infections (especially viral infections) in the cells coming from other individuals indicate that cellular therapy could meet obstacles during its development.

Genetic and peptidic therapy is based on the optimization of growth factors. It is possible to influence the process of ossification and osseointegration by including molecules with the implant that are able to create a quicker and more effective reaction in the osseous cells of the receiver or in those included in the transplantation, when the objective is to carry out the cellular therapy described earlier. The molecules can be introduced as purified proteins, such as DNA that induces the synthesis of the interest molecule in the cells of the patient (transfection), through the integration of the stem cells which will be transplanted. The molecules to be used for this aim could be those that are well noted for inducing ossification, such as TGF- β or bone morphogenetic protein 2 (BMP-2); alternatively, it might be possible to use new molecules or molecules for which a function in normal ossification is not known but which could be responsible, in a specific way, in terms of inducing osseointegration in titanium implants.

To identify the genes that preside over the synthesis of molecules involved in a particular way in osseointegration, Nishimura²⁸⁵ used a technique called *messenger RNA differential display polymerase*, which is a comparative examination of the messenger RNA present in different biologic conditions, for example, in the process of normal ossification and in the osseointegration of the implant. With this technique, it has been possible to identify three specific genes: They express themselves in the presence of titanium fixture and have been called TO1, TO2, and TO3, acronyms of T. Ogawa, who discovered them. These genes, other than at specific expression during osseointegration, have been shown to regulate the process in the two earliest phases and increase their expression in the presence of implants with a rough surface.

Nishimura²⁸⁵ observed that it is possible to re-cover the surfaces of the implants with the TO genes in a such a way that, after their insertion in the bone, small quantities of DNA are left in the tissue to favor osseointegration. The cells internalize this DNA and produce the corresponding growth factor more rapidly, with the result that the osseointegration process starts more quickly. These genes could open a new road for biologic research processes that regulate the mechanisms of osseointegration.

Conclusion

The clinical success of implants is strictly linked to the establishment and maintenance of osseointegration. The implant develops a dynamic relationship with the bone and the soft tissues that is subject over time to biologic and histologic changes. The topography and composition of the implant surface have been recognized as playing a fundamental role in the development and maintenance of osseointegration; the processes that regulate the establishment, the maintenance, and the stability of the relationships among the bone, soft tissue, and titanium still, however, are not completely known.

Biomechanical aspects certainly play a key role in the remodeling process that takes place around the implant as long as it exists; nevertheless, the effects of occlusal overloading have been decisively overvalued, maybe because the nature and the intensity of the occlusal forces examined during *in vitro* tests do not mirror the clinical reality. The effects that masticatory loads have on the mechanical restoration components are instead clear and relevant; considering the costs and the materials used in this restoration, it is necessary to increase resistance to fatigue to increase longevity.

Correct implant-prosthetic restoration must involve accurate planning, which ensues from the thorough accumulation of facts and information through history taking, clinical examinations, and radiographic examinations.

The progress made in the surgical field allows the realization of prosthetically guided restorations, with obvious esthetic and functional advantages, even where the osseous quantity is insufficient. It is important to stress, however, that in severe cases of bone atrophy, the use of advanced surgical techniques requires strong motivation by the patient and specific surgical competence of the operator.

The health of the peri-implant soft tissues is a key factor in the long-term maintenance of osseointegration. The process of integration of the implant must mature in a context of healthy soft tissues and in harmony with the residual structures.

The mechanisms of osseointegration still are the critical point on which research is centered: Immediate loading represents the first aim; the literature concerning this protocol seems to confirm, in some cases, the possibility of rehabilitating patients with just one surgery and a dramatically reduced length of time.

Evidence-based scientific research will, in the next few years, rescue the art of implantation, the current state of which has been cynically defined by Brunski⁴² as a myriad of different types of implants, used for an enormous variety of clinical situations, in unknown loading conditions, and in bone that differs in quality and quantity, but that in some manner heals.

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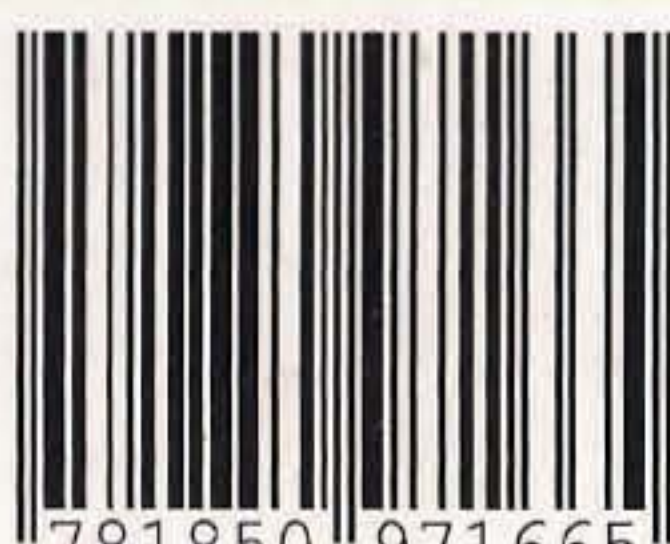
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Giulio Preti, MD, DDS, began teaching at the University of Turin in 1974, where he later became assistant professor. In 1980, he was asked to the University of Los Angeles (UCLA) as a visiting scholar, and, in 1987, he was made Full Professor at the University of Turin. Dr Preti also served as the Dean of the School of Dentistry from 1993 to 1996 and directed the Hospital of the School of Dentistry from 1996 to 2006. In 2006 he was made a Professor Emeritus of the University of Turin. Dr Preti is a Founding Member and Past President of the European Academy of Craniomandibular Disorders as well as President of the Italian Prosthodontic Society, member of the Medical Academy of Turin, and Honorary Member of the Italian Academy of Prosthetic Dentistry. He has written more than a hundred articles, many of which have been published in international journals, as well as collaborated on several textbooks in Italian, Spanish, and English. Dr Preti has been invited as a featured speaker at conferences around the world and was recently profiled in an issue of the *International Journal of Prosthodontists*.

This seminal book articulates the new paradigm in the discipline and practice of prosthodontics, documenting a radical shift in clinical focus away from dental techniques and materials and toward a more biologic and patient-centered approach. Based on their 25 years of collective knowledge and experience, the authors guide readers through each step of this comprehensive approach to patient care. This book centers on the process of diagnosis, which demands equal consideration of patients' systemic, psychologic, and functional needs as well as basic knowledge of the other disciplines of dentistry.

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